Climate change and technology in a globalizing world

A study on how the Clean Development Mechanism facilitates introduction of climate friendly technology in Africa

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Abstract

Key words: Clean Development Mechanism, Climate Change, Technology Transfer, Globalization

During only a decade or so, the issue of climate and how it can be affected, positively or negatively, by technological change, has become one of the most debated issues on the global agenda. The Clean Development Mechanism (CDM) is among the tools developed by the international community to reduce GHG emissions and, at the same time, promote sustainable development in developing countries. The CDM allows industrialized countries to finance commercially driven projects in developing countries that reduce GHG emissions, and treat the reductions as their own. The focus of this thesis is to map factors that have influenced development of proposals to apply the Clean Development Mechanism (CDM) to introduce climate friendly technology to Africa, and to assess the nature of these projects and their potential for technology transfer.

During the course of writing the thesis, visits were made to the United Nations Climate Change Conference in Montreal (2005) and the Carbon Market Insight Conference in Copenhagen (2006). Material for CDM project reviews was collected i.a. during a field visit to Uganda (2005) and by access to the world's largest database on CDM projects, granted by Point Carbon.

The quantitative and qualitative analyses suggest that CDM as an instrument will promote investment in climate-friendly technology in Africa. At least one-third of the projects will include explicit transfer of such technology to Africa from a developed-world partner. Moreover, factors such as the existence of a host country framework for the CDM and other country specific factors will influence the development of CDM as well as technology inflow caused by CDM. This is important because the development and diffusion of climate friendly technologies is crucial for reducing GHG emissions and adapting to climate change.

Table of Content

Figures and tables

Acronyms

A/F	Afforestation / Forestation
AOSIS	Alliance of small island states
AU	African Union
bn	Billion
CER	Certified Emission Reduction Unit
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
CoP	Conference of the Parties
CoP/MoP	Conference of the parties serving as meeting of the parties
DNA	Designated National Authority
ECA	Economic Commission for Africa
€	Euro (= 7,95 Norwegian Kroner per April 2006)
EIT	Economies in Transition
EU	European Union
FDI	Foreign Direct Investment
G-77	Alliance group of 134 developing countries
GHGs	Greenhouse Gases
GCI	Growth Competitiveness Index
GDP	Gross Domestic Product
GNI	Gross National Income
GNP	Gross National Product
GWP	Global Warming Potential
HDI	Human Development Index
HFC	Hydrofluorcarbons
IGO	Inter-Governmental Organization
IPCC	Intergovernmental Panel for on Climate Change
JI	Joint Implementation
KP	Kyoto Protocol
LDC	Least Developed Country
mn	Million
Mt	Million (metric) tonnes
MW	Megawatt (one million watts)
NGO	Non-Governmental Organization
N_2O	Nitrous Oxide

OAU	Organization of African Unity
ODA	Official Development Aid
PDD	Project Design Documentation
PPP	Purhasing Power Parity
R&D	Research & Development
SF_6	Sulphahexfluoride
SSN	South-South-North
STS	Science, Technology and Society studies
UK	United Kingdom
UNCED	United Nations Conference on Environment and Development
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention for Climate Change
UNIDO	United Nations Industrial Development Organization
US and USA	United States
USD and US$	United States Dollars (=6.60 Norwegian Kroner per April 2006)
WMO	World Meteorological Organization
,	Decimal separator

1 Introduction

1.1 Theme

The focus of this thesis is to map factors that have influenced development of proposals to apply the Clean Development Mechanism (CDM) to introduce climate friendly technology to Africa, and to assess the nature of these projects and their potential for technology transfer.

Climate change is caused by increases in Green House Gases (GHGs) concentrations in the atmosphere due to industrialization (Botkin and Keller, 2003: chap 22). Several international treaties have been reached to abate climate change. These include the United Nations Framework Convention on Climate Change, and the Kyoto Protocol (UNFCCC, 2005:1-46). They represent an effort to reach a global consensus on how to resolve the global problem of climate change.

A unique aspect of the climate treaties is the fact that they contain relatively detailed provisions for how investments in technologies that mitigate climate change should be planned, documented, financed and implemented in a partnership between an industrialized country and a developing country. The CDM allows industrialized countries to finance commercially driven projects in developing countries that reduce GHG emissions, and treat the reductions as their own The treaties draw a formal distinction between industrialized ("Annex I") countries and non-Annex I countries. More precisely, the Clean Development Mechanism encourages the dispersion of technology along this axis; whilst Joint Implementation encourages dispersion of technology within the Annex I group (UNFCCC, 2005:1-46). Hence, the protocol provides a framework for globalization of climate friendly technology.

Although Africa's contribution to the increased concentration of GHGs in the atmosphere has been low, the occurrence of climate change might pose formidable challenges for African countries. Globalization has created challenges for African states, but has also opened up new opportunities for interaction and technological co-operation and a potential to stimulate technology transfer through the various mechanisms initiated under the climate change treaties.

Climate change has become a fast growing science worldwide, and now draws upon fields as diverse as natural science, economy, social science and law. For students of the relationship between science, technology and the society, climate change therefore offers a unique case on how these disciplines interact.

The focus of this thesis is to map factors that have influenced development of proposals to apply the CDM to introduce climate friendly technology to Africa, and to assess the nature of these projects and their potential for technology transfer. To study this, a three-part analytical framework was used. The first part explores the growth and distribution of CDM in Africa. The second part involves a study of 39 actual CDM projects and a quantitative analysis of the nature of these projects and their potential for technology transfer. The final part of the thesis explores factors that may have influenced development of CDM projects in 52 African countries.

1.2 Analytical strategy

With respect to methodology, this thesis uses both literature review and empirical data to establish the theoretical framework and study the causes of CDM occurrence in African countries.

The study uses comparative data between African countries. However, comparisons between Africa and other continents have not been a subject of the thesis. Conclusions from the thesis can therefore be applied for Africa, but not for other parts of the world.

Theorists have pointed out that a number of internal and external factors influence the development of commercial projects in developing countries. The thesis explores some of these factors, and tests their relationship with the empirical information on CDM projects. Linear correlation analysis is employed as an indicator of whether the various factors appear to have been significant for CDM development. The Pearson Correlation Coefficient is computed for each set of parameters.

The Pearson correlation coefficient is written:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y}$$

where $\bar{x}$ and a $\bar{y}$ are the sample means of x_i and y_i, s_x and s_y are the sample standard deviations of x_i and y_i and the sum is from i = 1 to n.

- The resulting coefficient expresses correlation in a range from –1,00 to + 1,00, where – 1,00 is a perfect negative correlation, + 1,00 is a perfect positive correlation, and 0,00 is no correlation.

- The following interpretations have been suggested:

Correlation	Negative	Positive
Low	-0,29 to –0,10	0,10 to 0,29
Medium	-0,49 to –0,30	0,30 to 0,49
High	-0,50 to –1,00	0,50 to 1,00

However, the interpretation of a correlation coefficient depends on the context and purposes. The Pearson Correlation Coefficient has certain limitations. First, it explores only linear relationships. Second, it does not document causality.

(Source: http://wikipedia.org and Microsoft Excel User Guide, 2000)

The nature and potential for technology transfer within the CDM projects was assessed mainly by empirical data on known CDM proposals in Africa, supported by relevant literature and theory where applicable.

I have completed three study trips during the process of writing this thesis. The first trip was to Uganda, where I focussed on the practical implementation of the CDM facilities in this African country. The second study trip was to the 11th climate change conference in Montreal, Canada in late 2005. In March, 2006, I participated in the annual Carbon Market Insights conference in Copenhagen, hosted by Point Carbon[1].

Certain methodological challenges had to be resolved. In particular, this related to;

- Data on CDM projects are not always available, as no complete data base exists over CDM projects on a world wide scale. The chosen solution was to gain access to Point Carbon's specialized data base, which is the world's largest resource on project-specific CDM information. Additional material was gathered from various web pages.

- General information on political, social and macro-economic indicators for African countries is occasionally scarce and/or unreliable, due to a lack of transparency and statistical capacity on the continent. Therefore, such information was derived from acknowledged sources, such as UNCTAD, UNDP, World Bank and others.

[1] Point Carbon is the leading provider of independent analysis, forecasting, market intelligence and news for the power, gas and carbon emissions markets (www.pointcarbon.com).

- CDM is a new concept, and the international project portfolio is in a nascent phase. This thesis therefore relies on information about planned projects, several of which have not yet been implemented. More than 220 project ideas and proposals have been identified in Africa, but only 39 have matured to a phase where a Project Design Document (PDD) have been developed. Continued research over a longer period of time will be needed to conclude whether the indicative findings of this thesis will hold true when applied on the project portfolio that will actually be implemented in the future.

- As for the question of the nature of CDM projects in Africa and whether they will facilitate technology transfer to African countries, the analysis is confined to projects at PDD level. This is because more information is needed for answering this question, and sufficient information is available in the PDDs. It was found that the subjects of the thesis would be best understood by reviewing all of these 39 projects, supplemented by a closer look at a few project examples for illustration purposes.

- As for the question of factors that have influenced project development through the CDM in Africa, the analysis uses all 220 projects as analytical basis.

- A wide range of potential relationships between CDM project development on the one side, and political, social, legal and economic factors on the other side, are conceivable. This thesis can only explore some of these potential interrelations. The selected parameters are explained in further detail under each relevant section.

- The thesis concentrates on the size of CDM project portfolios in African host countries, i.e. how *many projects* the various African countries have. Another approach would have been to focus on the volume of GHG emission reductions created by the CDM projects in each African country. The reason for choosing the former is because it is seen as a more informative variable when exploring the issue of the nature of CDM projects and their potential for technology transfer. A third option would have been to concentrate on investment size. This was found impossible due to lack of information on amounts to be invested.

The interface between climate change science, technological change and these disciplines' relationships with society has become an issue of vital importance and worldwide attention. The importance of the subject matter deserves a much more elaborate review than possible within the limited scope of this thesis. It is hoped, however, that the thesis can make a contribution toward describing how these fields interact in Africa.

1.3 Concept clarifications

1.3.1 Africa

The term "Africa" is a geographical convenience only. There is as much diversity of climate, landforms, cultures, and economic circumstances within the region as there are between it and, say, South America or Asia. Very few statements are valid for the entire continent. The generalities that follow must be read in that context.

1.3.2 Foreign Direct Investment (FDI)

United Nations Conference on Trade and Development (UNCTAD) defines Foreign Direct Investment (FDI) as *"an investment involving a long-term relationship and reflecting a lasting interest and control by a resident entity in one economy (foreign direct investor or parent enterprise) in an enterprise resident in an economy other than that of the foreign direct investor*" (UNCTAD, 2005:329).

1.3.3 Technology

Technology can be defined as both a) capital goods, tools, machinery, equipment and entire production systems, and b) technical knowledge or non-technical knowledge, information and experience related to methods and techniques of production of goods and services (Menghistu, 1988:8-16).

Climate friendly technologies are technologies which emit no or very limited GHGs (Lefevre, 2005:10). GHG-reducing technologies for energy systems and other sectors of the economy can be divided into three categories: energy efficiency technologies; low or no carbon energy production technologies, and carbon capture and storage ("sequestration") technologies (IPCC, Mitigation, 2001: chap 3).

For the purpose of this thesis climate friendly technology is seen as both technologies that emit no or limited GHGs and the knowledge, information and experience related to these technologies.

1.3.4 Technology transfer

Climate friendly technology transfer comprises a broad set of processes covering the flows of know-how, experience, and equipment for mitigating and adapting to climate change among different stakeholders such as governments, private sector entities, financial institutions, Non-Governmental Organizations (NGOs), and research and/or education institutions (IPCC, Mitigation, 2001: chap 5) Moreover, within the UNFCCC climate friendly technology transfer is often related to transfer between Annex I and non-Annex I countries (IPCC, 2000:9).

1.4 Chapter outline

Chapter 2 provides an introduction to the climate change issue in general, and the Clean Development Mechanism in particular, as an outline of the framework for the thesis.
Chapter 3 describes African countries and their vulnerability to climate change, as well as how they cooperate with other African countries, NGOs and IGOs on climate change policy issues, and the CDM. Chapter 4 reviews the growth and distribution of CDM project proposals in Africa and takes a closer look at a selected number of CDM project proposals and climate friendly technologies used in CDM projects. Chapter 5 looks at the nature of CDM project proposals and their potential for technology transfer in Africa, while Chapter 6 looks at different factors that might have influenced CDM development in Africa. Chapter 7 consists of concluding remarks.

2 Framework; Climate Change and CDM

Synopsis

This chapter provides an introduction to the climate change issue in a globalizing world in general, and the Clean Development Mechanism in particular, as the framework for the thesis.

Theorists view globalization as a process that enables and intensifies transfer of capital, technology, know-how, people and ideas across national borders. Meanwhile, there is a broad consensus among scientists that the world's climate is undergoing profound changes; that these changes can have dramatic effects on virtually all aspects of life on earth, and that technology is the cause of these changes but also holds the key to solving the problem.

The effects of GHG emissions are global. Although the sources of emissions are local, solutions should be developed within a global context. An international framework to mitigate climate change has been developed that mobilizes the resources of international co-operation between nation-states, Inter-Governmental Organizations (IGOs), Non-Governmental Organizations (NGOs) and private companies. Under the auspices of the international climate change treaties, several transnational mechanisms have been developed for this purpose. These treaties advocate technology transfer as a tool for combating climate change. The Clean Development Mechanism (CDM) attempts to create a "win-win" tool by stimulating projects that imply reductions in global GHG emissions, while at the same time promoting transfer of climate friendly technology and sustainable development in developing countries.

The CDM creates intercontinental partnerships between governments, private companies, IGOs and NGOs and can accordingly be seen as an illustration of globalization.

2.1 Climate change; the background

2.1.1 The scientific background of climate change

GHGs are naturally present in the atmosphere and serve to keep our planet habitable. (Botkin and Keller, 2003: chap 22).

The role of GHGs is related to absorption of long waved heat. Short waved radiation from the sun heats the earth, which subsequently radiates long waved heat. The GHGs absorb this long-waved heat; the heat is trapped in the atmosphere for a longer time than it otherwise would be and thus the temperature on earth increases. Without this process, the temperature on earth would always be below 0°C (Botkin and Keller, ibid).

Industrial development such as the generation of energy by burning of fossil fuels has increased the concentration of certain GHGs in the atmosphere significantly (UNEP, 2003:5).

The table below shows some of the most important GHGs in the atmosphere and how their concentrations in the atmosphere have been affected by human activities;

Table 1: Examples of changes in GHG concentration caused by human activities

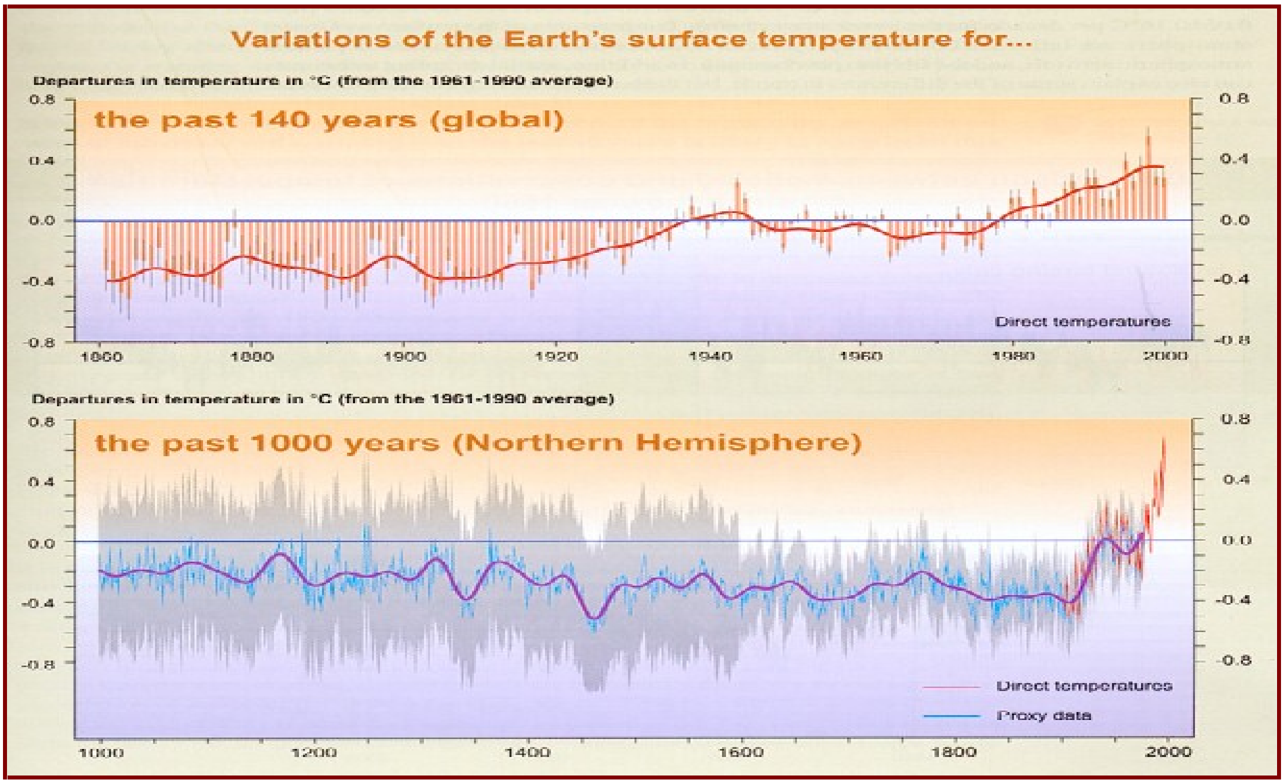
Gas Period	CO_2 (Carbon dioxide)	CH_4 (Methane)	N_2O (nitrous oxide)	HFC-23 (Hydrofluorocarbon-23)	CF_4 (Perfluoromethane)
Pre-industrial concentration	About 280 ppm	About 700 ppb	About 270 ppb	Zero	40 ppt
Concentration in 1998	365 ppm	1745 ppb	314 ppb	14 ppt	80 ppt
Global Warming Potential (GWP	1	23	296	12000	5700

(Note: ppm = parts per million, ppb = parts per billion, ppt = parts per trillion)

As seen in the table, some of the gases, such as HFC, are not naturally present in the atmosphere. The various GHGs differ in their ability to trap heat in the atmosphere. This is measured by their global warming potentials (GWPs) which is based on the radiative efficiency (heat-absorbing ability) of each gas relative to that of carbon dioxide (CO_2), as well as the decay rate of each gas (the amount removed from the atmosphere over a given number of years) relative to that of CO_2. CO_2 has by definition a GWP of 1, the other gases vary from a GWP of 12000 (HFC-23) to 23 (CH_4) (IPCC, the scientific basis, 2001).

The table below demonstrates how the increases in GHG concentrations have coincided with warmer mean temperatures (data from years 1000 – 2000);

Figure 1: Changes in the global average temperature



(Source: IPCC, scientific basis, 2001)

The mean global surface temperature has increased by about 0.3 to 0.6°C since the late 19th century and by about 0.2 to 0.3°C over the last 40 years. Recent years have been among the warmest since 1860 - the period for which instrumental records are available, and the warming is evident in both sea surface and land surface air temperatures. The impact of continued anthropogenic (man-made) increases in atmospheric GHG concentration has been estimated as an increase in global mean temperature from 1.4°C to 5.8°C by 2100. This temperature increase will cause changes in global precipitation patterns, shifts in climatic zones and an increase in extreme weather events. A further consequence of increased temperatures is sea-level rise due to both thermal expansion of water (warm water is more voluminous than cold water) and to melting of glaciers and permafrost. Human society will therefore have to find ways of adapting to the consequences of climate change. To stabilize the concentrations of GHGs in the atmosphere in order to prevent further climate change, emissions must be reduced on a global scale (IPCC, the scientific basis, 2001).

2.1.2 The international climate change treaties

In the United Nations environmental conference in Rio de Janeiro in 1992, negotiations led to the international treaty called United Nations Framework Convention on Climate Change (UNFCCC). The parties to the convention agreed to attempt prevention of further climate change. The convention separates between industrialized countries (Annex I), which carry the main responsibility for the problem of climate change, and developing countries (non-Annex I)[2] (see Appendix 1 to this thesis for articles in the Convention text, UNFCCC [online] from http://unfccc.int).

In 1997, further negotiations led to an international treaty called the Kyoto Protocol. In the Kyoto Protocol, industrialized countries (Annex I countries), but not developing countries, commit themselves to reducing their GHG emissions by a certain percentage calculated from their GHG emission levels in 1990. The emission reductions shall be completed before 2012 (Kyoto Protocol, 1997 [online] from unfccc.int). The table below shows GHG emission reduction targets for the Annex I parties to the Kyoto Protocol;

Table 2: Targets for changes in GHG emissions by Annex I countries, from 1990 to 2012.

Switzerland, Central and East European states, the European Union	-8 %
United States [3]	-7 %
Japan, Canada, Hungary	-6 %
Russia and Ukraine	0 %
Norway	+1 %
Australia	+8 %
Iceland	+10 %

(Kyoto Protocol, 1997 [online] from unfccc.int)

The signatories to the Protocol are governments; they have however developed different mechanisms for how they can impose their emission reduction targets on their national public and/or private entities. These mechanisms include emission quotas, taxes and other incentives. It is the enforcement of these national mechanisms in Annex I countries that create a commercial demand for emission reductions (Hasselknippe and Røine, 2006:5).

[2] The OECD countries are listed in Annex I but are also mentioned in Annex II and are therefore sometimes referred to as Annex II parties (UNFCCC [online] from http://unfccc.int).
[3] The United States has subsequently decided not ratify the Protocol (Hasselknippe and Røine, 2006:4)

2.1.3 Institutional Context

The principal forum for the scientific debate around climate change is the Intergovernmental Panel on Climate Change (IPCC). The IPCC was established in 1988 by United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO), as concern over climate change became a political issue. The purpose of the IPCC is to assess the state of knowledge on the various aspects of climate change including science, environmental and socio-economic impacts and response strategies (http://ipcc.ch). The principal forum for international policy debates is the negotiations within the UNFCCC and the Kyoto Protocol (Grübler, 1998:270-272).

Decisions regarding the Convention and the Protocol are taken when the parties to the UNFCCC and the Kyoto protocol meet to discuss and negotiate changes, elaborations and new issues. Since 1995, such negotiation meetings have been held once every year. They are called "Conference of the parties" (CoP). However, since all parties to the Convention are not necessarily parties to the Protocol (for example, USA and Australia) there must be separate meetings for negotiations under the Protocol. These are called "Conference of the Parties serving as Meeting of the Parties" (CoP/MoP) (UNFCCC, 2002:1-49).

In 2005, the first Cop/MoP was held at the same time as the CoP 11 in Montreal, Canada. Eight years passed between the signing of Kyoto Protocol and the first negotiation meeting, because the Protocol only entered into force when it had been ratified by Annex I Parties accounting for at least 55 % of the total Annex I CO_2 emissions. This happened when Russia ratified the Protocol on 16 February 2005 (UNFCCC, 2005:1-46). By 27 February 2006, 162 states and regional economic integration organizations (the European Union) had ratified the Protocol, while 189 states (and the EU) had ratified the Convention (http://unfccc.int, 2006).

In international negotiations, states often negotiate in different blocks that share common interests. In the international climate conferences, some of the main blocks are; the Alliance of Small Island States (AOSIS, consisting of 43 states); the EU states; the G-77 (consisting of 130 developing countries); and the umbrella group. The latter is not a formal negotiating block with a united position, but consists of certain states who are not part of any formal block (for example Norway, USA and Canada) (http://unfccc.int/parties). In addition to the official parties, International Governmental Organizations (IGOs) and Non-Governmental Organizations (NGOs) have the right to participate in the conferences as observers. By November 2005, over 600 NGOs had been accepted as observers (http://unfccc.int/parties_and_observers/ngo/).

It can be argued that these international treaties establish an international forum for technological change through cooperating on climate friendly technology development, technology transfer and diffusion of technology both directly and indirectly through the flexible mechanisms. Technologies have traditionally been transferred to developing countries through bilateral and multilateral development assistance, but with the climate change treaties new channels have been established (UNEP, 2003:61).

2.2 Globalization and climate change

There are some new trends in the world that we can call globalization. Globalization can be seen as the intensification of worldwide social relations in several institutional dimensions such as the world-capitalist system, the nation-state system, and the world military order as well as in the international division of labour (Giddens, 2000:92). However, why and how the globalization trends emerge, and the nature of their impacts, vary (Payne, 2004:11). Globalism can be defined as a state of the world that involves networks of multi-continental interdependence. These networks can be linked through flows and influences of capital, goods, information, ideas, and people, whereas globalization and de-globalization refers to the increase or decline of globalism. Although globalism is seen by many as a new phenomenon, it is an ancient process with many dimensions, of which one is economic, and others are military, social, cultural, and environmental. The globalization of today goes faster and deeper than in earlier historical periods. States are still the most important actor in international relations, but corporations and institutions are also part of this new global governance. The new global governance includes both formal and informal networks as well as learning and diffusion of norms (Keohane and Nye, 2000:2).

When globalization expands the political space, civil society actors may emerge to respond to the concerns of groups. During the last decades, there has been a significant increase in the number, activity, and visibility of international initiatives taken by civil society actors on a variety of issues. This emerging and increasingly influential class of economic, cultural and political actors – civil society organizations – is being shaped by and is itself shaping the processes of globalization. Civil society can further be defined as "*area of association and action independent of the state and the market in which citizens can organise to pursue purposes that are important to them, individually and collectively*" (Brown et al, 2000:275). Non-Governmental Organizations (NGOs) that seek to expand their influence beyond local and national boundaries can work across national borders or create transnational networks and coalitions with other NGOs. The increases of information flows, human travel and trade associated with globalization have made the formation and operation of NGOs and NGO alliances easier and less expensive (Brown et al, 2000:273-292).

Edoho (1997:99) argues that globalization and the new world order have transformed the environment of international technology transfer. Globalization is technology driven and technology oriented. Technology is both an enabling factor of globalization and a source of demand for more globalization. Advances in technology are transforming the dynamics of production, management, marketing and competition. As national economies become increasingly integrated, technology determines the global competitiveness and growth prospects of nation-states.

By definition, climate change is a global issue. Increasing concentrations of GHGs in the atmosphere will have global consequences (Botkin and Keller, 2003: chap 22)
Climate change is moreover an example of how technological development, depending on type and use of technology, can operate on a global scale and directly or indirectly change the global environment. Despite technological development being the source of the climate change problem, the paradox is that developing new technologies is also the solution. New technology is needed in order both to monitor, and to adapt to the effects of climate change. Furthermore, technological development in the form of end-of pipe technology or new, non-polluting technologies is needed to prevent further climate change (Grübler, 1998:342).

Simultaneously, the processes of globalization have led to environmental ideas, such as norms of good environmental governance and standards, and ideas on sustainable development, spreading worldwide. The issue of climate change is also an illustration of how environmental ideas have become global and important subjects in intercontinental relations. (Clark, 2000:87).

2.3 Investments and technology transfer and climate change

Studies within the field of science, technology and society (STS) have argued that a certain technological gap exists between states, and that there is a close relation between a country's economic and technological levels of development (Karake, 1990:104). Literature has focused on why and how some countries have technologically caught up with more technologically advanced countries, and/or why other countries have not succeeded in this (Fagerberg and Godhino, 2003:8). Research shows that industrialized market economies, economies in transition and developing countries have different introduction rates and adoption rates for new technologies (IPCC, Mitigation, 2001: chap 5).

Countries' adoption of new technology depends on factors such as a country's scientific and technological capability, the quality of its institutions, its economic conditions, and the dominant rules of behaviour, strategies and forms of organization of its economic actors. All these factors can be influenced by public policies as well as by other circumstances (Cimoli and Dosi, 1990:63). However, although success depends on technological capabilities, i.e. the capabilities to understand, adopt and improve upon imported technologies, acquiring access to and absorbing advanced technologies has in part determined countries' accumulation of wealth and power. This was part of the reason for the industrial success of the East Asian countries (Chang, 2004:4). International technology transfer is one strategy for narrowing the gap between global best practice and local technology. Recipients of technology transfer are driven by several motivations. One motivation is to increase the production of new and more innovative products in order to increase the added value or profitability of economic activity. Another motivation is to increase indigenous technological capability (Malecki, 1997:304). Developing countries have come to rely heavily upon technology transfer for investments in sectors such as energy infrastructure (IPCC, Mitigation, 2001: chap 5).

Capital for investment in technology flows from industrialized countries to developing countries through several paths such as multilateral and bilateral official development assistance (ODA), foreign direct investments (FDI), commercial sales, and commercial and development bank lending (IPCC, Mitigation, 2001: chap 3).

FDI represents a combination of capital, stock, know-how and technology, and is increasingly seen as a potential source of transferring advanced technologies from the industrialized countries to the developing countries. FDI has the potential of creating spill-over effects by diffusion of technology and know-how from the recipient firm to other firms in the host country (Portelli and Narula, 2003:7). FDI can thus play a constructive role in the development process by transferring capital, skills and know-how (UNCTAD, 2005:91). However, the link between FDI and development depends on whether the new technology becomes integrated in the host country's existing technological structure (Portelli and Narula, 2003:7).

Adapting to the consequences of climate change and reducing GHG emissions requires both technological innovation and new technological practices (IPCC, Mitigation, 2001: chap 5). Technologies and measures to reduce GHG emissions are continuously being developed. A number of new technologies and practices relating to buildings, transportation, industry, agriculture, and energy have gained importance (IPCC, Mitigation, 2001: chap 3). Technology transfer and technology change is therefore crucial for how the world can approach the climate change problem.

What is the relation between globalization and technology? The climate change issue is a complex process that includes a wide range of diverse interests, anticipated impacts, economic capabilities, technological capabilities and policy means associated with different governments, industries, interests groups, and individuals (Grübler, 1998:272). Climate change is a global problem that requires a global solution. Technological development is both the cause and the solution to the problem of climate change. If countries are to limit their emissions from their growing economies and adapt to the consequences of climate change, there will have to be a global switch to climate friendly technologies. Technology transfer will be among the tools for addressing this problem (UNEP, 2003:61). The climate change field is thus an example of how science, technology and changes in society are intertwined in global processes.

2.4 The Clean Development Mechanism

The Kyoto Protocol contains several flexible mechanisms designed to help the industrialized countries reach their emission reduction commitments in a cost-effective way as well as contribute to sustainable development and technology transfer between countries. One of these mechanisms is the Clean Development Mechanism (CDM) which is defined in the Kyoto protocol's Article 12, section 2 (Kyoto Protocol, 1997 [online] from unfccc.int).

Under the CDM, public or private entities from Annex I countries can invest in emission reduction projects in non-Annex I countries. Private entities may be authorized by their Annex I governments to carry out CDM projects and thereby contribute to meeting the country's emission reduction targets (UNEP, 2002:48). Subject to approval by the host country, external validators and the UNFCCC, the entity receives Certified Emissions Reduction units (CERs) for the actual volume of GHG emissions reduction achieved (UNFCCC, 2005:1-46). These CDM projects are the focus of this thesis.

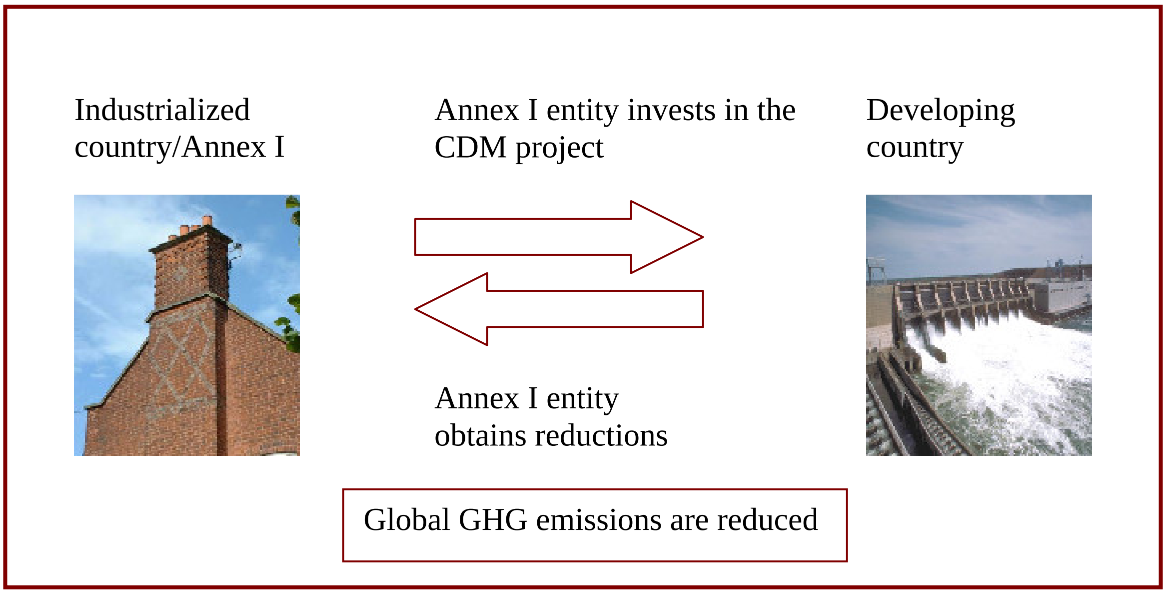
The other flexible mechanisms are;

(a) Joint Implementation (JI), defined in Article 6 of the Protocol, where Annex I countries or businesses can invest in GHG emission reduction projects in other Annex I countries, and

(b) Trading of surplus GHG emission reductions between Annex I countries, defined in article 17 of the protocol (Kyoto Protocol, 1997 [online] from unfccc.int).

The figure below shows how an Annex I private and/or public entity can invest in a GHG emission reduction project (CDM project) in a developing country and obtain GHG emission reductions;

Figure 2: The Clean Development Mechanism



(Figure: author)

2.4.1 CDM projects

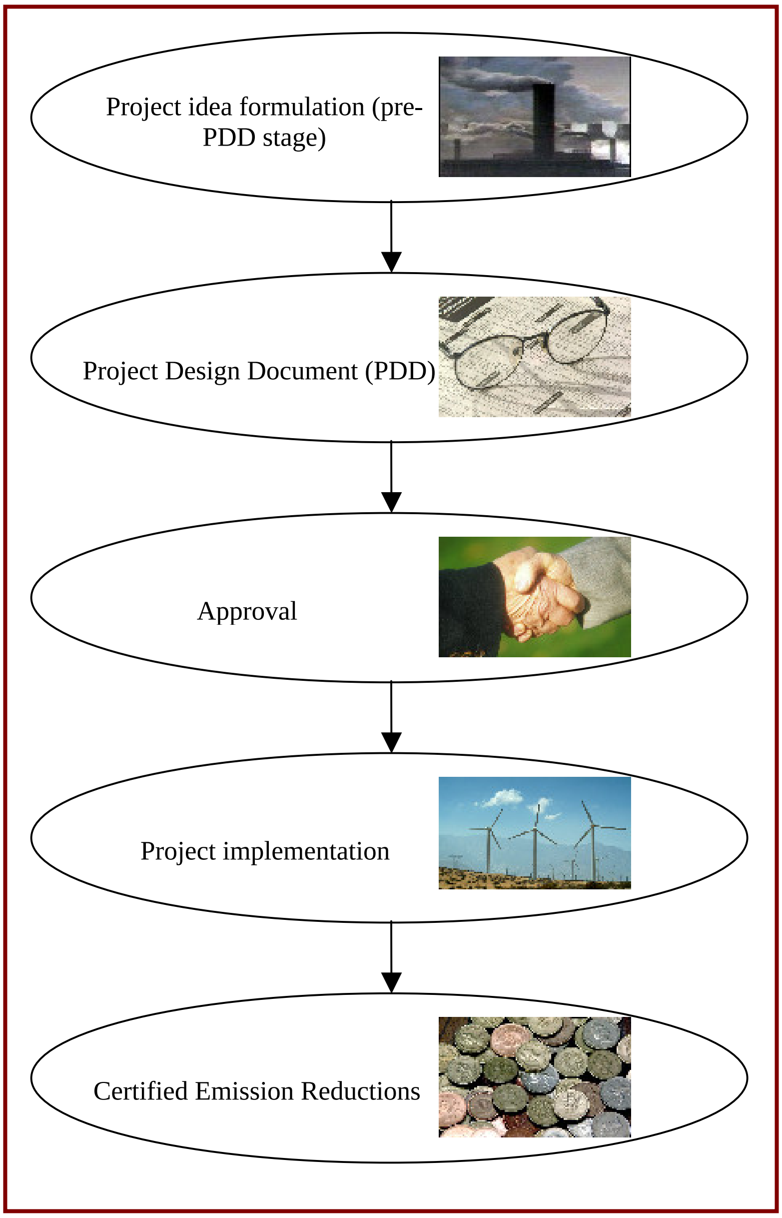
In order to participate in the CDM, there are certain eligibility criteria that non-Annex I countries need to meet. The three basic requirements are (1) voluntary participation in the CDM, (2) the establishment of a Designated National Authority (DNA) for CDM purposes, and (3) ratification of the Kyoto Protocol. The DNA is the host country body which evaluates CDM project proposals and provides written approval confirming that the project activity is voluntary, complies with national and international criteria and assists in promoting sustainable development in the host country. In addition, the DNA may also choose to perform some optional promotional functions centred on capacity building and marketing of potential CDM projects (Figueres, 2002:34).

For a CDM project idea to become a CDM project, the participants must design a Project Design Document (PDD) which contains details about the project activity, and have the documentation approved (validated) by an independent validator. The project documentation shall include a technical description of the project, and a description of how the project activity contributes to sustainable development, including how technology transfer, if any, will take place. The documentation shall further include a description of how the activity will result in GHG emission reductions and how these reductions (the project activity) are additional to what would occur in the absence of the activity (UNEP, 2002: 151-154).

The figure below shows the CDM project cycle and how a project idea evolves to a mature CDM project. The project participants (private and/or public entities) develop a Project Design Document

(PDD); they send it to an independent validator which approves this project documentation, the project participants also acquire project approval from host country DNA, and project approval by the UNFCCC. The project is implemented and the achieved GHG emission reductions are certified by the independent validator and the UNFCCC. The CDM project participants can retain the reductions for their own GHG reduction compliance or sell the certified emission reductions to other private and/or public entities (UNEP, 2002: 20-39).

Figure 3: CDM project phases



(Figure: author)

It has been emphasised that the CDM should trigger investment, speed up technology transfer and ultimately assist bring developing countries onto a less carbon intensive path of economic development (Egenhofer et al, 2005:1).Specifically, CDM projects can contribute to a developing country's sustainable development through the transfer of technology and financial resources, by fostering partnerships, by facilitating sustainable ways of energy production, by increasing energy efficiency and conservation, by enhancing poverty alleviation through income and employment generation, and by securing local environmental side benefits (Myung-Kyoon, 2004:12-16, Green et al, 2005:13).

The CDM can assist developing countries in acquiring the latest climate friendly technology and thereby overcome the financial burden of adopting and paying for climate friendly technologies. This gives developing countries the opportunity to leapfrog the so-called dirty stage of development (Green et al, 2005:13). Several different climate friendly technology types that mitigate GHGs are eligible under the CDM. Examples of these technologies include; renewable energy technologies (geothermal, hydro, wind and solar power technologies), clean transport engine technologies, landfill methane gas capturing technologies, energy saving technologies and technologies related to reducing HFC-23 gases or N_2O gases from industrial sites (Myung-Kyoon, 2004:98, UNEP, 2002:42, and http://cdm.unfccc.int/methodologies, see appendix 2 for a list of eligible project technologies).

Although transfer of climate friendly technologies is seen as one potential aspect of CDM projects (UNEP, 2003:151-154) some have argued that in reality, CDM projects are likely to be based on the diffusion of relatively mature climate friendly technologies rather than support the diffusion of comparatively new technologies. Reducing GHG emissions from one single, large source is often seen by investors as more cost-efficient than reductions that require several, dispersed initiatives on a smaller scale. CDM projects that reduce emissions from single, large emission sources (e.g. manufacturing plants) may therefore crowd out the technological push for technologies that could reduce GHG emissions on a broader scale in sectors where emissions are more dispersed, such as transportation and energy generation and use (Lefevre, 2005:15).

Some criticism has also been voiced with respect to the development aspect of CDM. It has been argued that there are no direct development benefits from large industrial end-of pipe CDM projects, and that although renewable energy projects do count for the largest number of projects, industrial projects (such as HFC-23 and N_2O decomposition) get a large share of investment due to their high GHG emission reduction potential (Cosbey et al, 2005: 13, Figueres, 2006:7, Olsen, 2005:13, Pearson, 2004). Figueres (2006:5) argues that the goal of achieving sustainable development is not being met by the CDM. She advocates a top-down sectoral CDM approach that could reform entire sectors such as energy efficiency and transportation. This “programmatic CDM” would represent a supplement to the current project based CDM.

2.4.2 CDM project participants

The CDM project participants comprise private and/or public entities involved in carrying out a CDM project. This includes host country entities and Annex I entities (UNEP, 2002:40).

The financial contribution of Annex I participants to CDM projects can be of a varied nature. Investments in CDM projects can be in the form of equity investments i.e. directly via joint venture companies or wholly owned subsidiaries, or indirectly through portfolio investments. The financial contribution can also take the form of purchases of yet-to-be-generated emission reductions, occasionally with an up-front payment. Emission reductions generated either by such financial contributions or generated unilaterally by project host country sources can be traded on secondary markets (Niederberger and Saner, 2005:4). The value of invested capital in a CDM projects by an Annex I entity should therefore not be confused with the value of GHG emission reductions transferred through CDM projects to an Annex I entity.

Investments in CDM projects or purchase of GHG emission reductions can also occur through private or public-private carbon funds. The World Bank has established and manages several different types of carbon funds, such as the Prototype Carbon Fund, a partnership between 17 Annex I companies and 6 governments, and the Italian Carbon Fund which is only open for participation of Italian private and public sector entities (http://carbonfinance.org/). UNDP has also established a carbon facility. This will direct financial flows to CDM projects in the least developed countries which will contribute directly to meeting the Millennium Development Goals (MDGs) (http://www.undp.org/climatechange/).

The total value of emission reduction transactions by the CDM in 2005 has been estimated at €1.9 billion. CDM projects that reduce HFC emissions comprised most of the transaction value, followed by projects in coal mine methane recovery technologies and renewable energy technologies. The remaining CDM projects included a wide range of technologies within animal waste, landfill gas recovery, and other energy technologies (Hasselknippe and Røine, 2006:22).

Some developing countries undertake CDM projects without the assistance of Annex I participants and sell the GHG emission reductions that have been approved. This is called unilateral CDM projects (UNEP, 2002:48). Unilateral projects have the advantages of increasing seller control of project development, and a possible increased sales price on CERs at a later stage. On the other hand, unilateral CDM by definition does not involve investments by foreign entities and the degree of technology transfer in the projects is therefore likely to be lower. (Egenhofer, et al, 2005:17).

2.4.3 Factors influencing CDM project development

As the CDM can be understood as a market mechanism, it has been argued that Annex I private and/or public entities will invest in CDM projects in non- Annex I countries with high potential for GHG emissions reduction, and countries with low GHG emissions will receive less CDM investments (Silayan, 2005: 24).

Moreover, CDM implementation requires that the host country establish a credible environment for project development that can attract foreign (Annex I) partners which is similar to what is needed to attract Foreign Direct Investment (FDI). This includes a stable macro-economy, low political risk, adequate infrastructure, access to large domestic and regional markets as well as strong domestic institutions and bureaucracy. Therefore it has been argued that the countries that are attractive for FDI are the same countries that are attractive for CDM projects (Cosbey, et al, 2005:31).

In assessing investment risk, an investor normally evaluates the enabling business environment. Countries with the desired business infrastructure, in terms of legislation and institutions, may have the advantage of attracting CDM project investors. This may lead to a preference for countries with stable political and economic conditions (Silayan, 2005:25-33).

Not all investment in CDM projects will be in the form of FDI, since projects may be financed unilaterally, with the Annex I partner only being the buyer of the GHG emission reductions. Furthermore, even though several CDM project are also FDI projects, FDI and CDM flows may not be guided by the same factors (Niederberger and Saner, 2005:9). The CDM differs from regular FDI in that there are other prerequisites for implementing CDM projects such as the establishment of a host country DNA (Cosbey, et al, 2005:31). Some countries with poor FDI performance are active in participating in CDM projects. This could be because they have invested in domestic capacity building for the CDM, and established host country's Designated National Authority (DNA) (Silayan, 2005:25-33). The overall investment climate may therefore not influence the more specific CDM investment climate.

Some theoretical literature presumes the level of human capital to be among the key ingredients of inward FDI (Miyamoto, 2003:16). As for the projects with a unilateral character there are certain factors that could influence host countries potential for developing unilateral CDM projects such as ability to mobilize domestic capital, a level of project risk management capability, existence of financing instruments, and a minimum of human infrastructure and institutional capabilities (Jahn et al, 2004:25-27).

2.4.4 The relation between globalization and CDM

The previous sections have described how CDM projects involve participants such as private and/or public entities from both developing countries (non-Annex I) and industrialized countries (Annex I), as well as support and assistance from IGOs and NGOs.

The CDM therefore creates intercontinental partnerships between governments, private companies, IGOs and NGOs and can accordingly be seen as an apt illustration of the globalization process described by Keohane & Nye (2000:2; see above). The market driven context of the CDM is an aspect of the globalization forces described by Giddens (2000:92).

3 Africa, climate change and cooperation

Synopsis

This chapter looks at how African states will be affected by climate change and how they have approached climate policy in general and CDM in particular within a global context.

Africa contributes very little to global GHG emissions, but will suffer severely from the effects of such emissions because its agriculture based economies are vulnerable to changes in the natural habitat. At the same time, the level of technological and economic development in Africa is low. The "win-win" potential of CDM projects in Africa is particularly strong because they can promote technology transfer to Africa and encourage sustainable development in African countries.

African countries take part in international networks within the climate change field, including CDM related negotiations, that involve co-operation with other developing states, regional cooperation bodies, IGOs and NGOs. Capacity building has been an important element in this process.

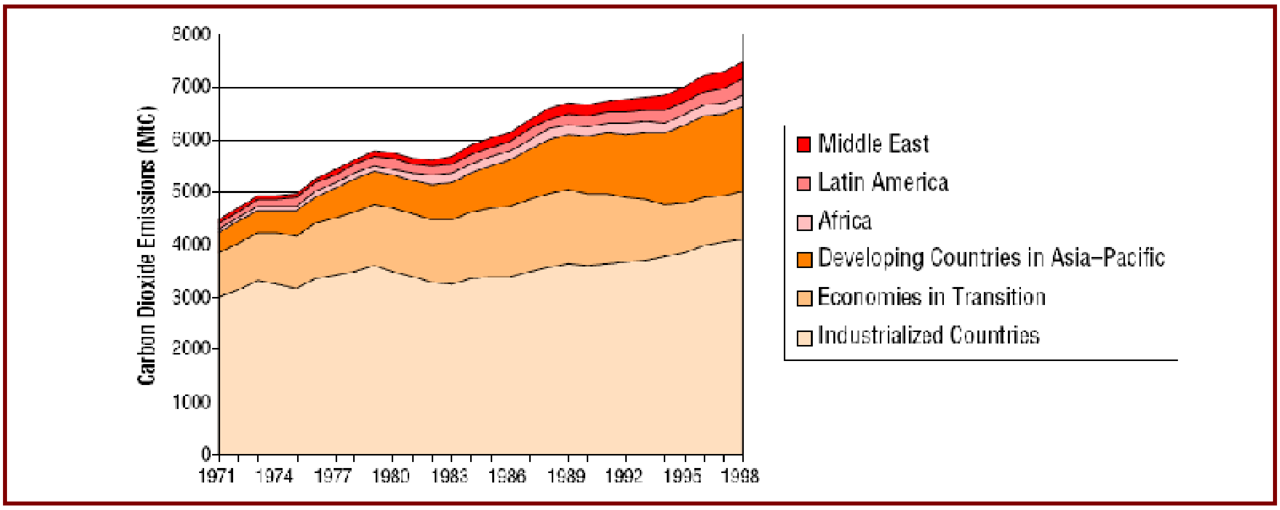
3.1 Africa and climate change consequences

Africa is the world's second largest continent. It is the oldest inhabited territory on earth and the human race originates from this continent. Today, Africa is home to over 50 independent countries, and more than 12% of the world's people live on the continent. Africa's role and participation in the global marketplace as well as in global organizations increases, and it is therefore important to examine how African countries influence and are influenced by global phenomena (Nnadozie, 2003:15).

The low level of economic development in some African countries, and the lack of such development in certain parts of the continent, has gained increasing international focus (Sachs, 2004:117, Artadi and Sala-i-Martin, 2003:3, UNCTAD, 2005:1). An economy develops when it is growing and transforming, and welfare is enhanced. UNDP has developed the Human Development Index (HDI), which is an indicator of welfare based on life expectancy at birth, adult literacy rate combined with education enrolment, and Gross Domestic Product (GDP) per capita in Purchasing Power Parity (PPP) terms. The HDI index ranges from 0 (lowest) to 1 (highest), and separates between high human development (range 1-0.8) medium human development (0.79-0.5) and low human development (range 0.5-0) (Nnadozie, 2003:33). In the African region in 2003, only one country (Seychelles) ranked among the high human development countries, in 52nd place, while 18 African countries were ranked among the medium development countries. The remaining African countries, however, were all in the low development country group. In fact, all 24 lowest HDI-ranked countries were African (UNDP Human Development Index, 2005: online from http://hdr.undp.org/statistics/).

To date, Africa's contribution to the increased concentration of GHGs in the atmosphere has been low, and the region does therefore not pose a major threat to the global climate (Eleri, 1997:265). The figure below shows Africa's contribution to GHG emissions compared with other regions;

Figure 4: World CO_2 emissions by region, 1971 - 1998



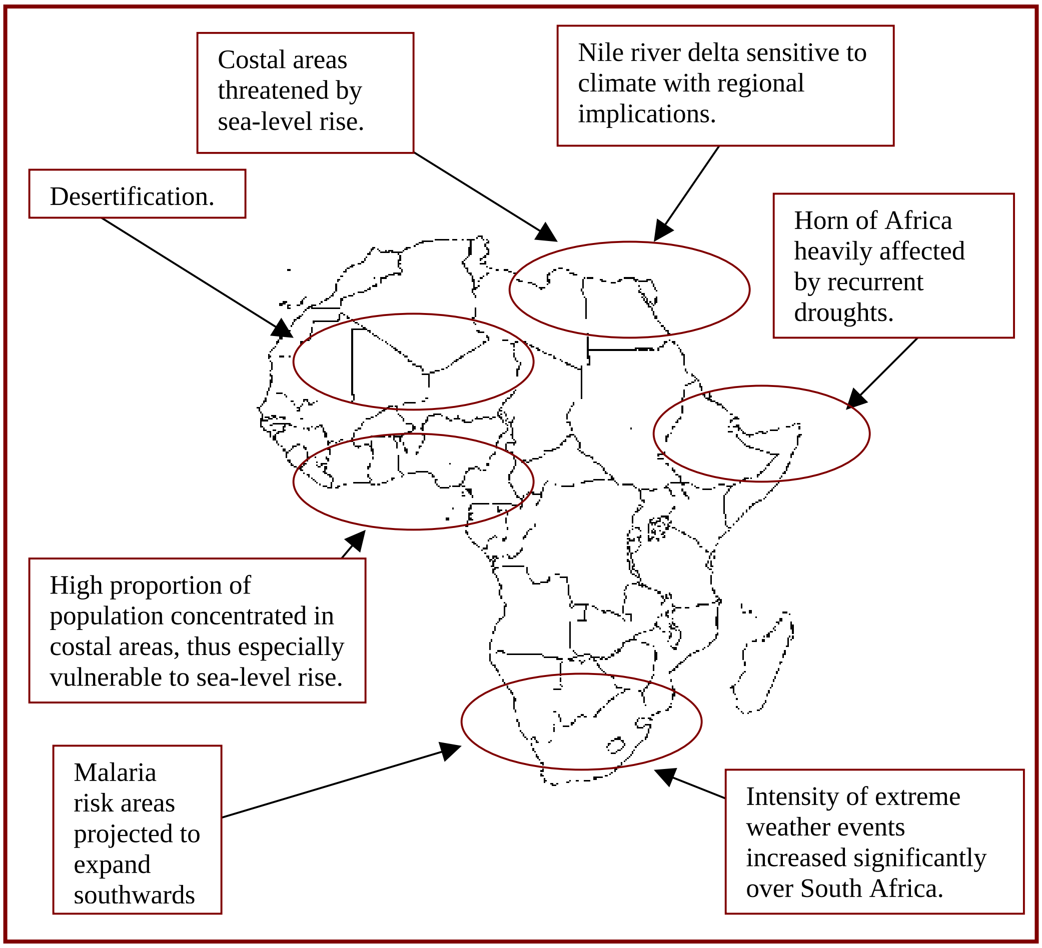
(Source: IPCC, Mitigation, 2001 chap 3)

However, the occurrence of climate change might pose formidable challenges to development in Africa (Eleri, 1997:265). Studies have underpinned the vulnerability of African countries to climate change, as a result of their limited adaptive capacity which is constrained by numerous factors at the national level. More specifically, climate change will affect African water resources because increased temperatures will enhance evaporative losses from rivers and lakes in the African region. Most of the rivers and lakes in Africa have a delicate balance between precipitation and runoff, and sensitivity analyses of major rivers on the continent indicate that they are sensitive to climate change (IPCC, Impacts, Adaptation and Vulnerability, 2001: chap 10).

Climate change may also cause events, particularly droughts and floods, that will have severe effects on African agriculture. Agriculture is not only a vital source of food in Africa; it is also the prevailing way of life. An average of 70% of the population lives by farming, and 40% of all exports are earned from agricultural products. Moreover, because climate change can alter the patterns of temperature and precipitation, the two most fundamental factors determining the distribution and productivity of vegetation, other likely impacts may be geographical shifts in the ranges of individual animal and plants species, with associated changes in productivity. This renders vulnerable the large part of the African population which depends on forest species for subsistence and the part of the economy that is based on forest products (ibid.).

Other challenges can result from the impacts of extreme weather events such as tropical storms, landslides, wind, cold waves, and sea-level rises. These events are likely to increase management problems relating to pollution, sanitation, waste disposal, water supply, public health, infrastructure, and technologies of production. Africa as a continent is thus likely to be most seriously affected by climate change (ibid.).
Possible consequences of climate change for Africa are shown below;

Figure 5: Key impacts for Africa of climate change



(Source: IPCC, Impacts, Adaptation and vulnerability, 2001:45);

The processes of adapting to global climate change, including technology transfer, offer new development pathways that could benefit from Africa's resources and human potential (IPCC , Impacts, Adaptation and Vulnerability, 2001: chap 10). The CDM could be a tool for technology transfer (Green et al, 2005:16). As Africa needs technological development to secure economic development, this can be seen as a reason for participating in the climate treaties.

Processes of globalization transform the nature and form of political power today (Held and McGrew, 2000:107) and globalization has created both opportunities and challenges for African states. African individuals and policy makers continue to construct creative and original responses to meet their political, economic and social needs. What is happening in Africa is the practice of politics in complex and original ways (Dunn, 2001:3).

3.2 Africa and cooperation on climate change

3.2.1 Regional co-operation

Regional bodies such as the Economic Commission for Africa (ECA), the former organization of African Unity (OAU, now the African Union, AU), and the Sudano-Sahelian Countries have been important actors in strengthening regional environmental perspectives. An example of this was their cooperation prior to the UN conference on Environment and development (UNCED) in 1992 (Eleri, 1997:273). Six years later, after the Conference of the Parties in 1998, several African states established a process to strengthen the African negotiation capacity in the climate change field through regional cooperation in a project coordinated by the International Institute for Sustainable Development (www.issd.org). Following this, in February 2005, several African ministers met in Nairobi to discuss the upcoming climate negotiations in Montreal. The result of the meeting was a joint statement that outlined African priorities in post-Kyoto negotiations. The inclusion and strengthening of the African Union in the further climate change negotiations was defined as a main strategy (UNEP, 2005).

3.2.2 NGO co-operation

Climate change is a problem where international NGOs and alliances are relevant. Research suggests that international NGOs and alliances help formulate and implement many international decisions and policies by mobilizing people and resources for international action on important problems. Just as countries vary considerably as to how open they are to the impacts of globalization, countries vary in the extent to which civil society organizations are active in national life (Brown et al, 2000:275).

African environmental NGOs have engaged in regional climate change workshops and conferences. African NGOs have generally focused on the development component of climate change and have urged for active African participation in climate change negotiations. They have provided sources of information, analysis and training for policy-makers. Several activities relating to climate change are taking place in Africa, and despite the divergence of interests, important initiatives are being taken by regional bodies, NGOs, sub-state actors and the media (Eleri, 1997:281).

One initiative taken is by SouthSouthNorth (SSN), a network of organizations, research institutions and consultants that helps public and private stakeholders build capacity and develop CDM projects. SSN operates in several African countries such as South Africa, Tanzania, and Mozambique (http://www.southsouthnorth.org/). However, interaction between policy-makers and NGOs varies within and between countries (Eleri, 1997:281).

3.2.3 IGO co-operation

IGOs have played a significant role in global environmental problems, and the networks of connections running through IGOs dealing with environmental issues have been strengthened during the last decades. This has been done in part by the inclusion of organizations that previously had little interest in environmental issues (such as the World Bank) and by IGOs developing a deeper level of professionalism and skills (Clark, 2001:99).

Climate change policy and the flexible mechanisms have become an area of increasing cooperation between African states and IGOs. There exists a multitude of cooperation projects and programmes, many with various UN organizations and the World Bank (Green et al, 2005:35).

Some of these capacity- and partnership building cooperation projects and programmes are described in further detail below (financial facilities, have been described in section 2);

UNEP has launched the project "Capacity Development for the Clean Development Mechanism" with financial support from the Dutch Government. The project aims at 1) generating a broad understanding of the opportunities offered by the CDM in developing countries and 2) developing the necessary institutional and human capabilities that allow developing countries to formulate and implement projects under the CDM. Twelve countries, in four developing regions, have been selected to participate in the project. African participants include Egypt, Morocco, Côte d'Ivoire, Mozambique and Uganda (http://www.cd4cdm.org/).

UNDP has cooperated with African states on several initiatives related to climate change in the Africa region. One of these initiatives was the "Engaging the private sector - learning by doing CDM capacity development in South Africa" project that was completed in 2003. Another initiative is the "Adaptive capacity project in Mozambique" program which is currently being discussed with the Government of Mozambique. UNDP has also organized workshops and training seminars in Africa on climate change (http://www.undp.org/climatechange/).

United Nations Industrial Development Organization (UNIDO) has finished a "Capacity building for CDM" project, where Ghana, Kenya, Nigeria, Senegal, Zambia and Zimbabwe participated, and has now established the "Demonstration Project for 10 African Francophone Countries on the CDM". The objective of the latter project is to provide training and advice to the national governments and one representative from the private sector in each of the ten sub-Saharan Francophone countries. This will comprise enhancing knowledge of the potential for increased flows of FDI and technology transfer under the CDM; improving capacity to manage the processes related to the CDM project cycle; and enhancing ability to identify, develop and prepare industrial CDM projects to a level where they can be picked up by investors (www.unido.org/doc/3941).

United Nations Conference on Trade and Development (UNCTAD) has a "Getting started with CDM in Least Developed Countries (LDCs)" project which in Africa targets Tanzania, Uganda, Mozambique, Zambia and Malawi. The project tries to promote CDM investment and facilitate CDM projects in the targeted countries (www.unctad.org).

The World Bank has a "Africa - Assist - Special Effort in Africa" programme, designed to foster new partnerships between selected African countries, regional and international organizations, donors, and civil society. The objective of these partnerships is to build capacity in about a dozen Sub-Saharan African countries. The core focus lies on facilitating CDM project development (http://carbonfinance.org/).

4 The growth and distribution of CDM in Africa

Synopsis

This section looks at the growth and distribution of CDM project proposals in Africa. The section also provides illustrations of CDM project propsals and climate friendly technology types suggested in African CDM projects.

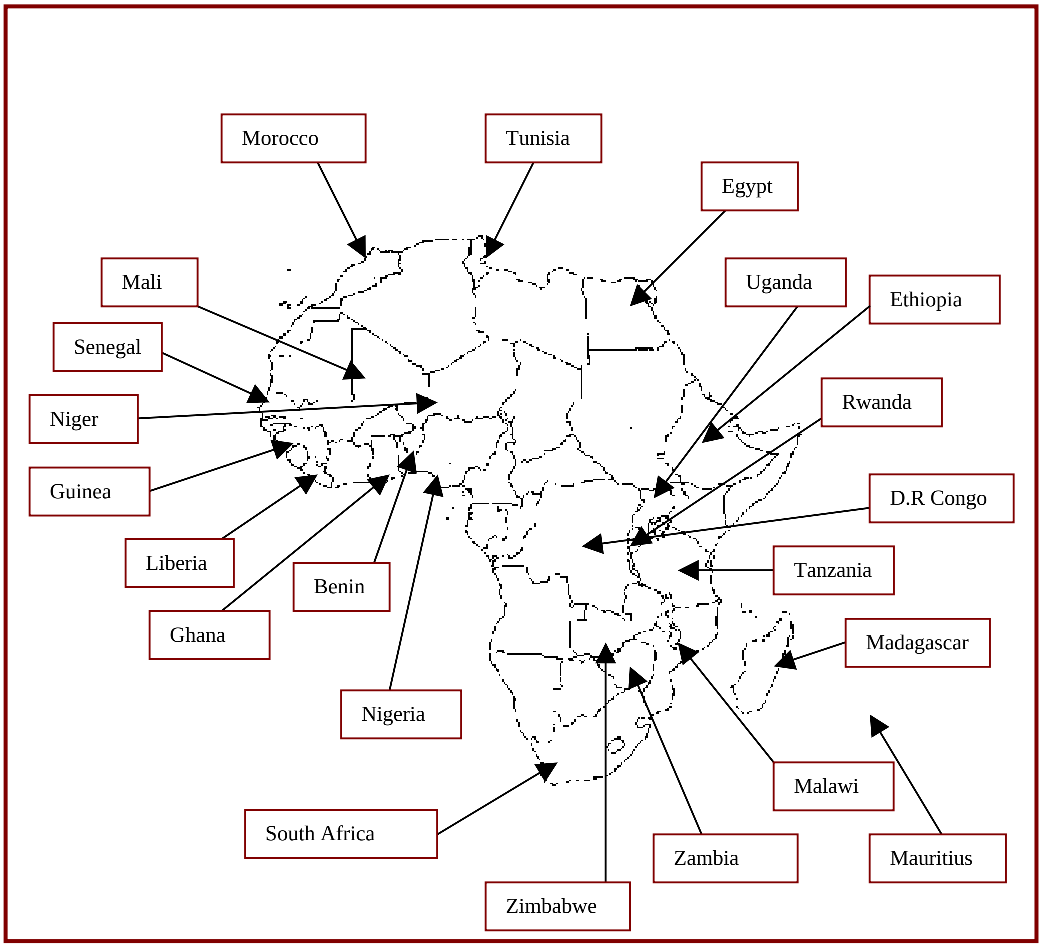
In 2005, total payments for GHG emission reductions under CDM were estimated at €1.9 billion worldwide. Africa' share of the market was very low. However, the number of CDM project proposals in Africa is growing.

A total of 22 African countries have developed an institutional CDM framework in the form of Designated National Authorities (DNAs), and over 200 project proposals have been identified in 29 African countries. A total of 39 project proposals were identified which had matured to a phase where a Project Design Document (PDD) has been developed.

4.1 CDM distribution in Africa

African states prepare for participation in the CDM by establishing DNAs. The number of African DNAs has increased significantly lately, and 22 African states (see table 4) have now notified the UNFCCC that they have a DNA in place ([online] at: http://cdm.unfcc.int).

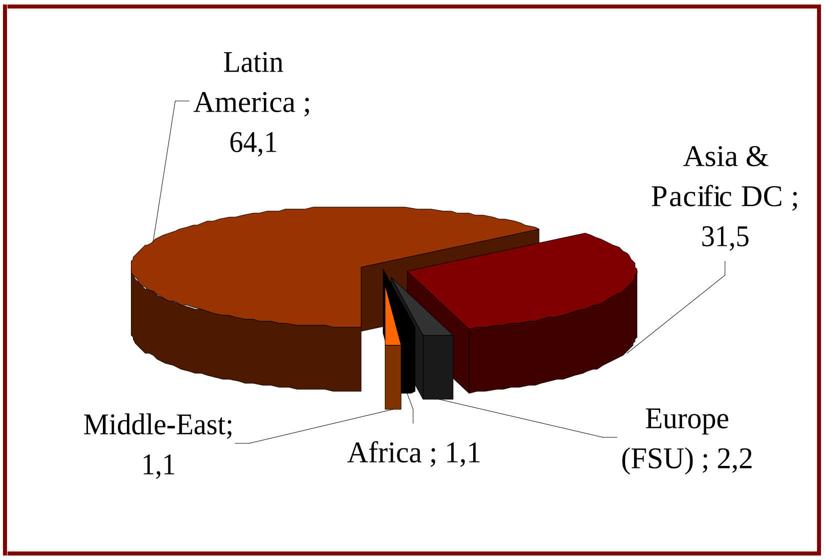
Table 4: African states with DNAs



(Figure: author)

To date, Africa has received a minor portion of CDM investments, and in 2005 only a small part of CDM projects being developed took place in Africa (Africa investor, October 2005:17). The table below shows an estimate of the worldwide distribution of project proposals with PDD in April 2005 (Cosbey et al, 2005:23);

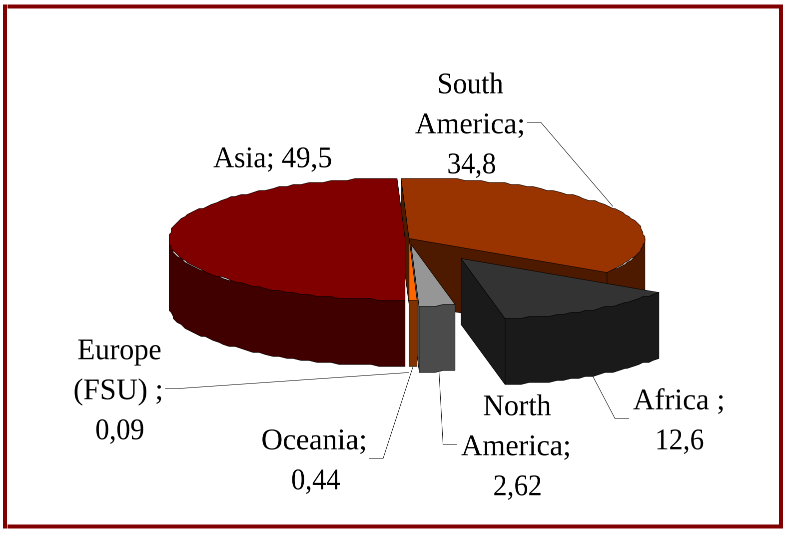
Figure 6: Regional distribution of CDM projects with PDD (per cent), 2005



(Source: Cosbey et al 2005: 23)

This table shows that in the early phase of CDM, most projects were launched in Latin America. More recent data suggests that project development activity in Africa has since gained considerable momentum. This is evidenced by the following graph, which shows the distribution of known project proposals, including projects at pre-PDD phase, in February 2006;

Figure 7: Regional distribution of CDM projects at PDD and pre-PDD phase, per cent 2006

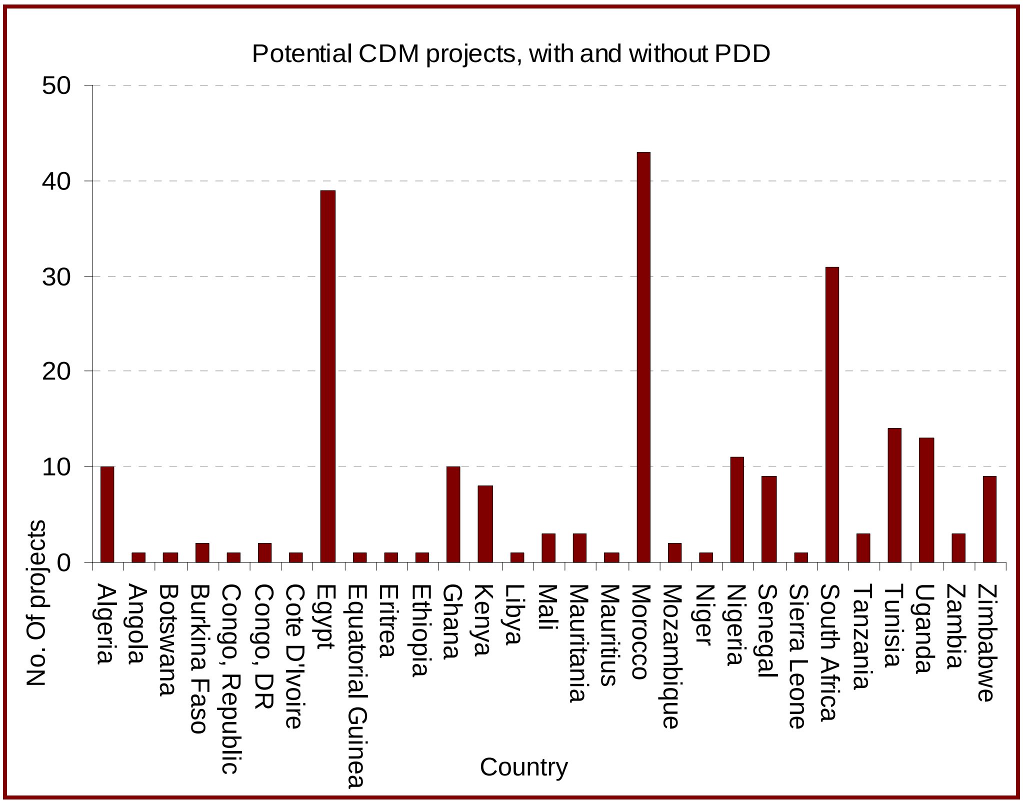


(Source: Point Carbon Project Database, 2006)

These data from 2005 and 2006 cannot be compared directly, since they are not based on a uniform project definition. However, the data do indicate that Africa's share of the worldwide CDM portfolio has increased, and that the continent has a large number of pending projects in the pre-PDD phase, which implies that more PDD-level projects will emerge from Africa in the near future.

Point Carbon has identified a total of 226 CDM project proposals in 29 African countries. These project proposals are at all phases of development, from project idea formulations (pre-PDD phase) to projects with PDD, and fully implemented and approved projects (http://www.pointcarbon.com). The distribution in number of CDM project proposals, with and without PDD, among the African countries is shown below;

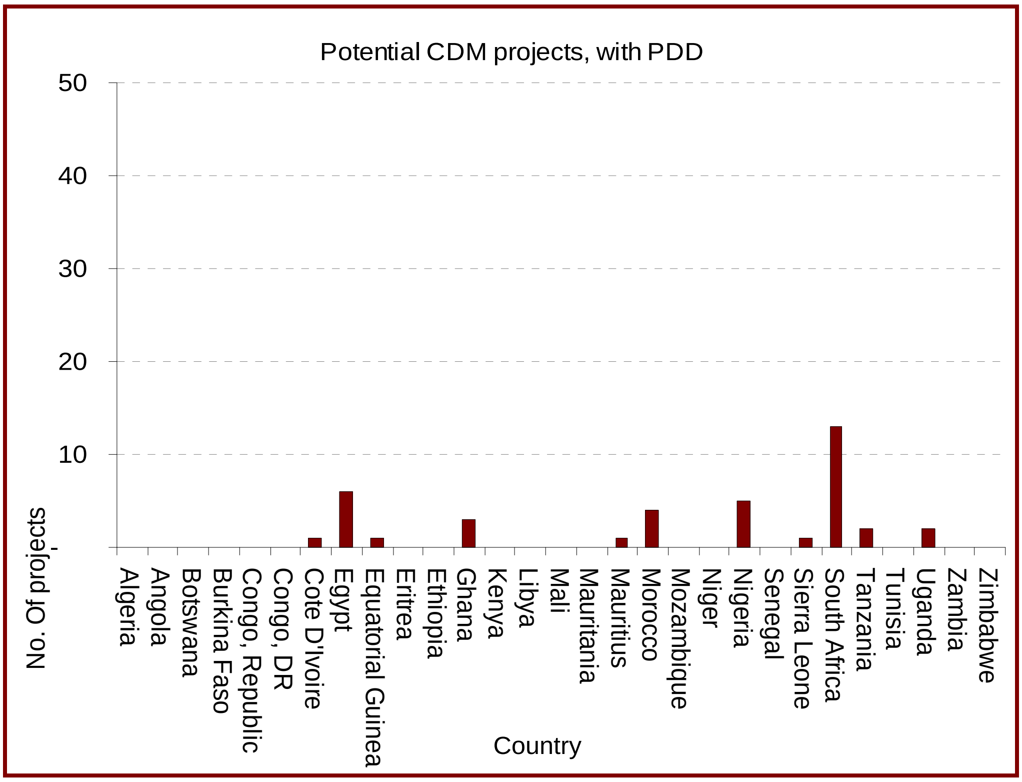
Figure 8: CDM project proposals in Africa identified as of February 2006



(Source: Point Carbon Project Database, 2006, http://www.pointcarbon.com)

Out of these 226 project proposals, a total of 39 have developed a PDD. The country-wise distribution is as follows;

Figure 9: CDM project proposals in Africa with PDDs, identified as of February 2006



(Source: From www.unfccc.int, www.dnv.com, www.cdmegypt.org, www.netinform.de www.sgsqualitynetwork.com)

It is worth noting that out of the total 226 project proposals, only 39 (17%) have yet developed a PDD.

Country-specific data indicates that the distribution of proposals with PDD is broadly similar to the distribution of projects in all phases of development. However, there are some very interesting variations. The North African countries of Egypt, Libya, Algeria, Tunisia and Morocco combined have 107 projects (47% of the total) when projects in all phases are counted. However, the same four countries have reached PDD phase for only 10 of these projects; i.e., 26%. It is therefore notable that more projects in sub-Sahara Africa could appear to progress to PDD phase than projects in Northern Africa. This might be explained by country-specific factors in sub-Sahara that enable projects to develop more easily, or by the possibility that the project portfolio in Northern Africa has been conceived at a later point in time and is therefore still moving towards the PDD phase. Since details on project "age" at pre-PDD phase are not publicly available, firm conclusions on this cannot be drawn without further research.

4.2 CDM illustrations

4.2.1 Waste management

Projects involving changes in the management of municipal wastes offer opportunities to reduce emissions of methane (CH_4), an especially potent GHG, as well as to displace consumption of fossil fuels that generate CO_2. Although methane emissions represent a very small part of aggregate emissions to the atmosphere, the GWP of methane (21 times that of CO_2) means that emission reduction projects offer correspondingly greater benefits (Hoyt, 2002:96). An estimated 50–80 Mt CH_4 was emitted by solid waste disposal facilities (landfills and open dumps) and wastewater treatment facilities in 1990 worldwide (IPCC, 1996:14).

Although there are large uncertainties in methane emission estimates for a variety of reasons, overall emissions levels are projected to grow significantly in the future (IPCC, 1996:14). Reductions of methane emissions and displacement of CO_2 emissions from waste management projects occur when solid waste landfills generate methane as the natural by-product of decomposition of organic material in the solid waste. In developing countries, solid waste generation tends to include a higher percentage of organic material, as opposed to plastics, metals, glass, paper and other types of materials. Accordingly, the potential for obtaining methane gas from landfills located in population centres in developing countries is significant. However, the volume of extractable landfill gas depends on the extent to which a landfill is adequately sealed and managed to avoid gas seepage directly into the atmosphere and ensure gas quality over time. Depending on the methane content of the landfill gas extracted, landfill gas extraction projects make it possible for most facilities to generate fuel for small generation units to produce electricity and/or steam for various uses (Hoyt, 2002:96).

To the extent that power and thermal energy produced in this way is used in displacing electricity produced by fossil-fired generation facilities or in place of fossil or biomass fuels, such projects yield reductions of uncontrolled methane emissions and CO_2 emissions from fossil fuel combustion. The exact degree to which the project reduces total GHG emissions will depend on the type of fuel used for energy production prior to switching to landfill or waste gas and the extent of uncontrolled methane emissions prior to the project (ibid.).

Technical options to reduce methane emissions do exist and may, in many cases, be implemented profitably (IPCC, 1996:14) The feasibility of implementing projects involving the recovery or production of methane gas for use as fuel will, however, depend on a series of socioeconomic linkages and dynamics. These issues include environmental and sanitary regulations in the host countries, the availability and cost of alternative sources of electric and thermal energy, the social and economic opportunity costs of recovering energy content of waste streams, allocation of investment resources in urban infrastructure and public services, opportunities for private investment in infrastructure and public services and public opposition to specific types and locations for public or private infrastructure development. The extent to which these factors inhibit the implementation of projects in the waste management area varies significantly from nation to nation and may even vary from city to city within a given country (Hoyt, 2002:96).

There are ongoing landfill gas recovery projects in Tanzania, Côte d'IvoireSouth Africa, Ethiopia, Ghana and project ideas are emerging in Kenya and other countries in Africa. There are many waste management projects in urban development; however, their main focus is waste management and not the recovery of energy from waste. CDM can make the landfill gas recovery and utilization project attractive to investors (Urban Solid Waste Management project 2003, worldbank.org). Several CDM landfill gas projects are now being developed in Africa. The section below will describe two CDM projects in Africa which could contribute to transfer of waste management technology to the host countries.

4.2.2 Project illustration

Landfill gas recovery at Mtoni Dumpsite, Dar Es Salaam, Tanzania

The project involves installation of a landfill gas capture system at the "Mtoni Dumpsite" site, using a proven technology according to EU requirements. The technology to be employed includes a gas collection network, biogas monitoring and control equipment; electrical connections to the public grid; and a biogas-fuelled generator. The project activity is the "first of its kind" in Tanzania and is therefore a climate friendly technology demonstration project. The Annex I participant is the Italian based company Consorzio Stabile Globus which will act as the project developer and provide the technology and training of labour. The developer will transfer the technology to the Urban Authority within Dar Es Salaam City Council, which will benefit from technology and know-how transfer. The project is thus meant to enable Tanzania to leapfrog to new sustainable and affordable technologies (Source www.dnv.com/).

United Republic of Tanzania- Key facts

Population: 36 mill (2005 est.)

GDP per capita: 700 $ purchasing power parity (2005 est.)

GNI per capita: 330 US$ (2004)

Poverty (% of population below national poverty line): 36% (2002 est.)

Life expectancy at birth (years): 45.24 years (2005 est.)

Literacy (% of population 15+): 78.2%

Structure of the economy (% of GDP, 2004 est.): Agriculture: 43.2%, Industry: 17.2%, Services: 39.6 %

Import of goods and services: (% of GDP): 27% (2003)

Export of goods and services (% of GDP): 18% (2003)

FDI net inflows (2003): 248 million US$

High-technology exports (% of manufactured goods): 2 % (2002)

(Source: www.cia.gov/factbook, worldbank.org, undp.org)

Akouedo Landfill Rehabilitation and Electricity Generation Project; Abidjan, Cote d`Ivoire

The objective of this project is to collect and utilize the landfill gas of the existing landfill and of a new sanitary disposal that will be built adjacent to the current site to accommodate the future waste produced. The project will provide a model for managing landfill gas, a key element in improving landfill management practices throughout the host country, and will act as a clean technology demonstration project, encouraging less dependency on grid-supplied electricity from fossil fuel sources.

The technology to be transferred includes a gas collection system, a drainage system, flaring equipment and a modular electricity generation plant. The Annex I participant is EcoSecurities, a UK private company that develops CDM projects. The developers are partnered with several other companies; Soletanche Bachy, a French company that will be responsible for the lining, drainage system and final cover of the current landfill site; Biothermica Energie Inc, a Canadian based company that will install the gas collection system, flares and electricity generation system; Tianjin Machinery corporation, a Chinese company that will install the gas collection system on part of the current landfill site and finance part of the project; Tescult International Ltd, a Canadian company in cooperation with the host country's department of development, will oversee the works on the landfill site (Source: http://www.dnv.com).

Cote d`Ivoire - Key facts

Population: 17.2 million (2005 est.)

GDP per capita: 1,400 US$ purchasing power parity (2005 est.)

GNI per capita: 770 US$ (2004)

Life expectancy at birth (years): (2005 est.): 48.62 years (2005 est.)

Literacy (% of population 15+): 50.9 % (2003 est.)

Structure of the economy (% of GDP, 2004 est.): Agriculture: 27.7%, Industry: 16.7% Services: 55.6%

Import of goods and services (% of GDP): 33% (2004)

Export of goods and services (% of GDP): 42% (2004)

FDI, net inflows (2003): 179.8 million US$

High-technology exports (% of manufactured goods): 8% (2003)

(Source: www.cia.gov/factbook; worldbank.org, and undp.org)

The combination of partners from countries as diverse as United Kingdom, France, Canada and China to implement a project in Cote d'Ivoire, and of Italian partners in Tanzania, are examples of the globalized nature of CDM. This seems to confirm the statement that environmental ideas have become global and important subjects in intercontinental relations. (Clark, 2000:87).

5 Climate friendly technology transfer in African CDM projects

Synopsis

This section asseses the nature of 39 actual CDM project proposals that have evolved to a phase where a PDD has been developed. This section also reviews the potential for technology transfer within these 39 projects.

The list of CDM project proposals has been retrieved through public sources and probably includes almost all African CDM project proposals that have matured to this phase. These proposals are used to assess the nature and extent of technology transfer to African countries that is likely to be caused by the CDM facility.

The project ortfolio of project proposals indicates that 31 of the 39 projects (79%) are within various parts of the energy sector (renewable energy, energy efficiency or landfill gas recovery). The remaining proposals are within the industry sectors and forestation sectors. This shows that industry projects have, as of yet, shown limited potential for CDM in Africa, whose industrialization still lags behind.

Around 50% of the projects have been initiated in the host country, and have not yet officially been partnered with an Annex I participant. This could indicate that the host country has had sufficient technological skills to formulate the project concept. The remaining projects have involved an Annex I participant in the project development phase. The Annex I participants included private entities (such as companies), public entities (such as governments or government procurement vehicles) and semi-private funds.

13 of the proposals (around 36%) include defined technology transfer components. This can be understood to confirm that CDM will facilitate transfer of climate friendly technology to Africa. Although the remaining 64% of the proposals have no explicit technology transfer component, these proposals may nonetheless include technology transfer at a more modest scale, or technology transfer limited to the national level.

The findings indicate that CDM proposals conform broadly with the characteristics of globalizations processes defined by globalization theorists. It involves public, private, semi-private and intergovernmental institutions (see Keohane & Nye; 2000); and it creates partnerships between participants from several continents in the exchange of environmental ideas (see Clark, 2000). Edoho's (1997) argument that globalization is a self-reinforcing process cannot be proven yet, since CDM remains in a formative stage, but it is a theoretical indication that CDM will continue to evolve in volume and depth on the African continent.

5.1 Project proposals reviewed

This section makes an empirical review of the 39 identified African CDM project proposals that have progressed to PDD phase. All projects that advance to a certain phase, i.e. develops a PDD, must be subject to public hearing (UNEP, 2002:1-46). Therefore, information is publicly available through different web pages, and the list is believed to be almost complete. The PDDs for these projects provide information required to assess the extent of technology transfer and other characteristics that are important for the subject of this thesis. Such information is not available for projects that have not yet matured to the PDD phase. Analyses were therefore confined to proposals with a PDD.

The following analysis was prepared (references included in footnotes)[4],

Table 3: African projects with PDD; Annex I Participation

Country	Project	Annex I participant
Cote d'Ivoire	Akouedo Landfill Rehabilitation and Electricity Generation project[5]	Yes; UK company
Egypt	Abou Zaabal Fertilizers, Waste Heat Recovery Enhancement for Cogeneration and Fuel Substitution project[6]	No
	Al Sindian Paper Mill Cogeneration project[6]	No
	El Nasr paper and carton plant cogeneration project[6]	No
	Fayoum 22 bricks kilns fuel switching project[6]	No
	Fuel switch at Shoubra Elkama glass company project[6]	No
	Zafarana 120 MW Wind Power Plant project[7]	Yes; Japanese government through Japan Bank for International Cooperation
Equatorial Guinea	Reduction of Flaring and Use of Recovered Gas for Methanol Production project[7]	Yes, UK company

4 (Note that USA has not ratified the Kyoto Protocol and US companies can therefore not be an official Annex I participants);

5 www.dnv.com

6 www.cdmegypt.org

Country	Project	Annex I participant
Ghana	Conversion of single cycle to combined power generation project [7]	No, a US company is a consultant
	Efficient lighting retrofit project [7]	Yes, several German companies
	Mandatory Energy-Efficiency Standard for Room Air Conditioner project [7]	No, a US company is a consultant
Mauritius	Chicose landfill project[8]	No,[8] World Bank Prototype Carbon Fund was participant
Morocco	Essaouira 60 MW Wind Farm[5]	Yes, German government through a loan, a UK company is a consultant
	Jorf Lasfar heat recovery enhancement for power project [5]	No
	Solar homes systems for rural electrification project [9]	No
	Tetouan 10.2 MW Wind Park [5]	Yes, French company
Nigeria	Displacing grid/off-grid steam and electricity generation with less carbon intensive fuels in Aba project [7]	Yes, Italian government through World Bank fund
	Reduction of Transmission and Distribution Losses project [7]	Yes, Italian government through World Bank fund
	Reducing SF_6 Emissions in High-Voltage Transmission/Distribution Systems project [7]	Yes, Italian government through World Bank fund
	Recovery of associated gas that would otherwise be flared at Kwale oil-gas processing plant [5]	Yes, Italian company
	The Ovade Ogharefe Gas Capture and Processing project [5]	No, a Scandinavian company is a consultant
Sierra Leone	Bumbuna Hydroelectric project [7]	Yes, the World Bank fund
South Africa	Bethlehem Hydroelectric project[10]	Yes, World Bank Prototype Carbon Fund
	Cape Town Low-Income Housing Upgrade project [5]	No
	Durban Landfill gas to electricity project [9]	Yes, World Bank Prototype Carbon Fund
	Lawley fuel switch project [5]	No
	Mondi Gas Turbine Co-generation project [7]	No
	Mondi Richards Bay Biomass project [10]	No
	PetroSA biogas to energy project [7]	No

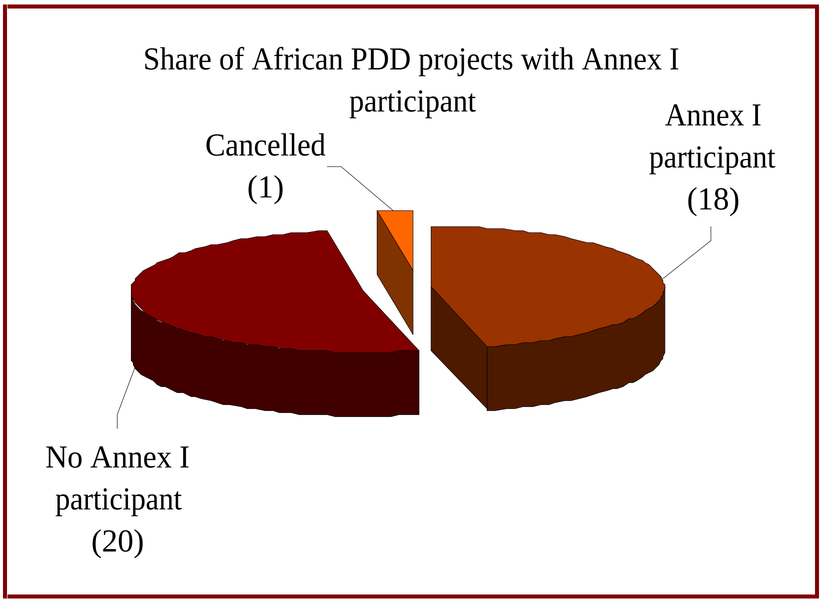
[7] www.cdm.unfccc.int/methodologies
[8] Project has been dropped by the World Bank Prototype Carbon Fund (http://www.cdmwatch.org/project)
[9] www.netinform.de
[10] http://www.sgsqualitynetwork.com/

Country	Project	Annex I participant
	Rosselyn fuel switch project [5]	No
	Coal to natural gas feedstock conversion for large-scale manufacture of Pure gas at Sasol project [7]	No
	Sasol Nitrous Oxide Abatement project [7]	No
	Bellville south landfill gas recovery project [5]	No
	Transalloys manganese alloy smelter upgrade and energy efficiency project [7]	Yes, a UK company
	Emfuleni Power project [5]	No
Tanzania	Landfill gas recovery at Mtoni Dumpsite project [5]	Yes, Italian company
	Small group and tree planting project [7]	Yes, World bank BioCarbon Fund
Uganda	West Nile Hydropower project[10]	Yes, World Bank Prototype Carbon Fund
	Kikonda forest Reserve reforestation project [7]	Yes, German company

(Source: www.dnv.com, www.cdmegypt.org, www.sgsqualitynetwork.com, www.netinform.de, cdm.unfccc/methodologies)

This review found that 20 project proposals (57 % of the total) do not yet have an Annex I participant. This implies that the project to some extent has a unilateral character. The remaining 43 % of the projects did however have an Annex I participant. The results are shown in the figure below;

Figure 10: Number of projects with Annex I participant



A further analysis of the results shows certain disparities between countries that have developed projects on a largely unilateral basis, and countries that have drawn upon Annex-I partners. This is shown in the table below;

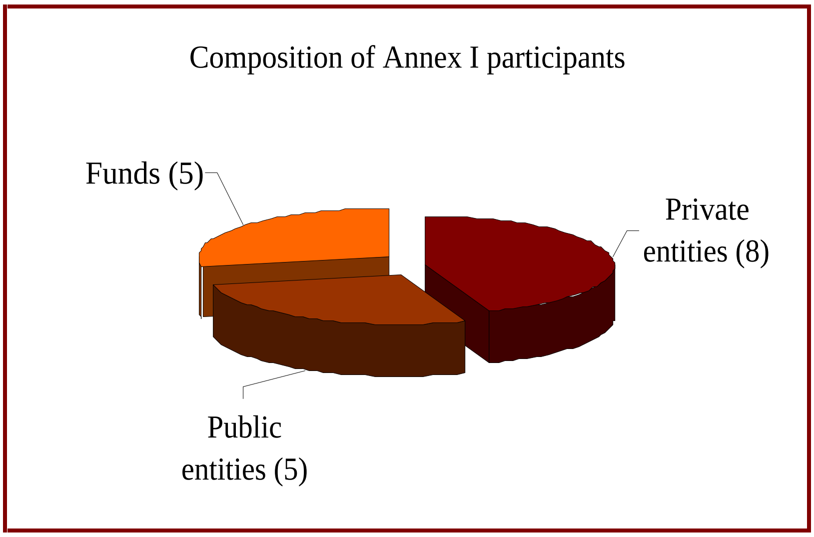
Table 4: Countries and extent of proposals with Annex I participants (per cent)

Countries where >50% of CDM proposals have an Annex-I partner (multilateral project development)	Countries where <=50% of CDM proposals have an Annex-I partner (unilateral project development)
Cote d'Ivoire (100%)	Egypt (16%)
Equatorial Guinea (100%)	South Africa (23%)
Uganda (100%)	Ghana (33%)
Tanzania (100%)	Morocco (50%)
Sierra Leone (100%)	
Nigeria (80%)	

These results indicate that i.a. South Africa and Northern Africa (Egypt and Morocco) have been able to develop a PDD-phase portfolio without the presence of an Annex-I partner. Countries in sub-Sahara Africa have to a much larger extent relied on partnerships with Annex-I countries. In fact, this indication becomes even stronger when one considers that although not all projects have an official Annex I investor, several projects have assistance from a foreign partner, such as the "Ovade Ogharefe Gas Capture and Processing Project" (Nigeria), where a Scandinavian company acts as a consultant (www.dnv.com), and "Conversion of single cycle to combined power generation" and "Mandatory Energy-Efficiency Standard for Room Air Conditioner" projects (both in Ghana), which both have a US based company as a consultant (www.cdm.unfccc.int/methodologies).

Another interesting finding was that the Annex I participants were evenly distributed among private sector entities (such as private companies) and public sector entities (such as governments and government procurement vehicles) as well as from different semi-private funds. The figure below shows the composition of Annex I participants;

Figure 11: Composition of Annex I participants



This analysis demonstrates that CDM is a valid illustration of the globalization theorems formulated by theorists such as Keohane and Nye, (2000:2). *("States are still the most important actor in international relations, but corporations and institutions are also part of this new global governance. The new global governance includes both formal and informal networks as well as learning and diffusion of norms" (ibid.).* The CDM has brought forward combined efforts by public institutions, private corporations, semi-public institutions and IGOs to plan and develop a portfolio of African CDM projects.

5.2 Technology types and technology transfer

An analysis of all project proposals was also made to determine whether they include technology transfer components, as well as the profile of applicable climate friendly technologies to be introduced to the projects.

To enable this analysis, it is necessary to define the term "technology transfer component". For the purpose of this thesis, "technology transfer component" is defined as being present in cases where the project participants themselves state in the PDD that the project will include a component of technology transfer. And, since the general understanding of technology transfer in the UNFCCC context implies participants from both Annex I and non-Annex I countries, proposals without an Annex-I participant as of yet will hence not be defined as having a technology transfer component.

The nature of technology transfer in these projects can also be influenced by differences in the roles of the Annex I participants. If further researched, questions as to how the different participants are

involved in the projects and if differences exist as to which participants provide for technology transfer and by what means, should be investigated.
Other important questions that could be further researched include; will the projects be implemented?, will the projects be successful in acting as clean technology demonstration projects?, and will there be any further technological (including know-how) spill-over effects to other African countries, companies or sectors from these projects? These questions can only be researched at a later time, when more projects have actually been implemented, and practical impacts can be observed.

As for the question of the nature of technology and technology transfer components in CDM proposals in Africa at this point in time, the following analysis was prepared (references included in footnotes);

Table 5: African projects with PDD; Technology and Technology Transfer Component(s)

Country	**Project**	**Technology type**	**Technology transfer component**
Cote d'Ivoire	Akouedo Landfill Rehabilitation and Electricity Generation project[11]	Waste Management	Yes
Egypt	Abou Zaabal Fertilizers, Waste Heat Recovery Enhancement for Cogeneration and Fuel Substitution project[12]	Energy efficiency	No
	Al Sindian Paper Mill Cogeneration project[12]	Energy efficiency	No
	El Nasr paper and carton plant cogeneration project[12]	Demand-side energy efficiency and fuel switching	No
	Fayoum 22 bricks kilns fuel switching project[12]	Fuel switching	No
	Fuel switch at Shoubra Elkama glass company project[12]	Fuel switching	No
	Zafarana 120 MW Wind Power Plant project[13]	Renewable energy	Yes
Equatorial Guinea	Reduction of Flaring and Use of Recovered Gas for Methanol Production project[13]	Reduction of fugitive emissions	No
Ghana	Conversion of single cycle to combined power generation project [13]	Energy efficiency	No

11 www.dnv.com

12 www.cdmegypt.org

[13] www.cdm.unfccc.int/methodologies

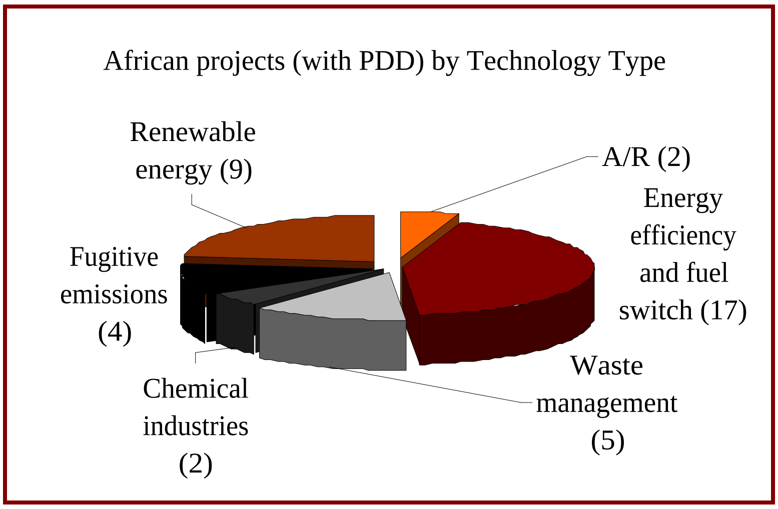
Country	Project	Technology type	Technology transfer component
	Efficient lighting retrofit project [13]	Energy efficiency	No
	Mandatory Energy-Efficiency Standard for Room Air Conditioner project [13]	Energy efficiency	No
Mauritius	Chicose landfill project[8]	Waste Management	No
Morocco	Essaouira 60 MW Wind Farm[11]	Renewable energy	Yes
	Jorf Lasfar heat recovery enhancement for power project [11]	Energy efficiency	No
	Solar homes systems for rural electrification project [14]	Renewable energy	No
	Tetouan 10.2 Mw Wind Park [11]	Renewable energy	Yes
Nigeria	Displacing grid/off-grid steam and electricity generation with less carbon intensive fuels in Aba project [13]	Energy supply	Yes
	Reduction of Transmission and Distribution Losses project [13]	Energy efficiency	Yes
	Reducing SF6 Emissions in High-Voltage Transmission/Distribution Systems project [13]	Reduction of fugitive emissions	Yes
	Recovery of associated gas that would otherwise be flared at Kwale oil-gas processing plant [11]	Reduction of fugitive emissions	Yes
	The Ovade Ogharefe Gas Capture and Processing project [11]	Reduction of fugitive emissions	No
Sierra Leone	Bumbuna hydroelectric project [13]	Renewable energy	Yes
South Africa	Bethlehem Hydroelectric project[15]	Renewable energy	No
	Cape Town Low-Income Housing Upgrade project [11]	Energy efficiency	No
	Durban Landfill gas to electricity project [14]	Waste Management	No
	Lawley fuel switch project [11]	Fuel switching	No
	Mondi Gas Turbine Co-generation project [13]	Energy efficiency and fuel switching	No
	Mondi Richards Bay Biomass project [15]	Renewable energy	No
	PetroSA biogas to energy project [13]	Renewable energy	No
	Rosselyn fuel switch project [11]	Fuel switching	No
	Coal to natural gas feedstock conversion for large-scale manufacture of Pure gas at Sasol	Reduction from Chemical industries	No

[14] www.netinform.de
[15] http://www.sgsqualitynetwork.com/

Country	Project	Technology type	Technology transfer component
	project [13]		
	Sasol Nitrous Oxide Abatement project [13]	Reduction from Chemical industries	No
	Bellville south landfill gas recovery project [11]	Waste Management	No
	Transalloys manganese alloy smelter upgrade and energy efficiency project [13]	Energy efficiency	Yes
	Emfuleni Power project [11]	Energy generation in industry	No
Tanzania	Landfill gas recovery at Mtoni Dumpsite project [11]	Waste Management	Yes
	Small group and tree planting project [13]	Afforestation and Reforestation	Yes
Uganda	West Nile Hydropower project[15]	Renewable energy	No
	Kikonda forest Reserve reforestation project [13]	Afforestation and Reforestation	No

As an initial measure for the study of the project portfolio's technology level, the key project technologies were indexed and categorized according to technology types, adopting applibale parts of the UNFCC categorization of technology attached in Appendix 2. The analysis found that that a relatively high number of the CDM projects in Africa are planned within the sectors of energy efficiency and renewable energy[16]. The categorization gave the following result;

Figure 12: Projects divided by technology type

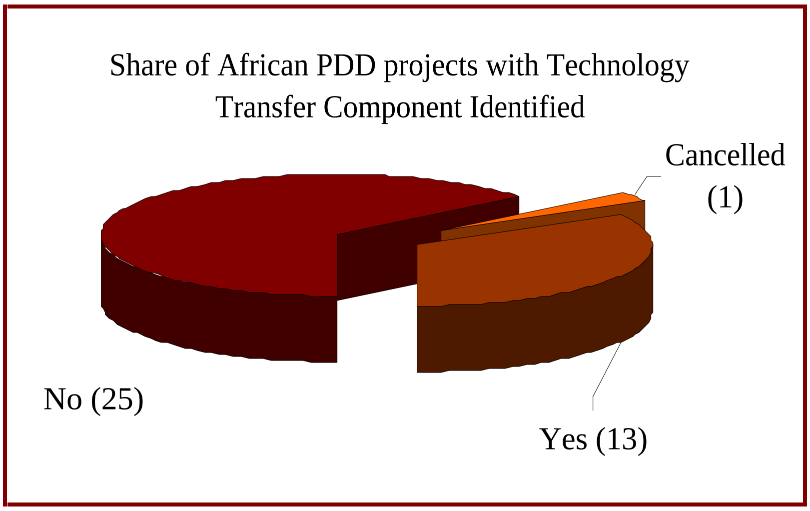


[16] A/F refers to Afforestation and Reforestation projects

The analysis indicates that 31 of the 39 projects (79%) are within various parts of the energy sector (renewable energy, energy efficiency or landfill gas recovery). The remaining projects are within the industry sectors and forestation sectors. This shows that industry projects have, as of yet, shown limited potential for CDM in Africa, whose industrialization still lags behind.

Another primary finding is that although 45 % of the project did specify an Annex I participant, only 36% of the projects have technology transfer components that are substantial enough to be described explicitly in the PDD. The remaining projects may however include technology transfer components on a more modest scale, which have gone unmentioned in the PDD. Furthermore, funding might at a later stage provide transfer of technology due to payments from emission reductions. In addition, these projects might contribute to sustainable development by other means such as creation of jobs or less environmental degradation. Moreover, technology transfer can take place internally in countries and not just between countries and/or private companies in different countries. Many of these projects may have elements of internal technology transfer. More research would therefore be needed to substantiate these initial findings further.
The findings are summarized in the figure below;

Figure 13: Projects with technology transfer component identified



To summarize, the findings indicate that 36% per cent of the African CDM projects will facilitate technology transfer. Moreover, the projects with a technology transfer component were not clustered in one or two countries, but nearly all the African countries with projects that had developed a PDD had project(s) that will transfer climate friendly technologies to the country. The exceptions were Uganda, with its two projects, and Equatorial Guinea with its one project. Furthermore, almost all technology types were represented among the projects with a technology transfer component.

Edoho (1997:99) argues that globalization is a transforming aspect in the environment of international technology transfer. Edoho sees globalization is technology driven and technology oriented, and predicts that as national economies become increasingly integrated, technology determines the global competitiveness and growth prospects of nation-states. The analyses have shown that CDM conforms broadly with definitions of globalization. It might therefore be expected that CDM will continue to represent an increasing contribution to the globalization processes and climate-friendly technological development processes of African countries.

As a consequence, the diffusion of climate friendly technologies to African states may increase. In line with Malecki`s (1997:304) argument that international technology transfer is one strategy for narrowing the gap between global best practice and local technology, this section confirms that the CDM will facilitate transfer of climate friendly technologies to African countries and thereby contribute to decreasing the technological gap between industrialized and African countries, which may in turn contribute to the economic and sustainable development of the African continent.

Consequently, although the relative portion (both in total and compared to other regions) of technology transfer resulting from CDM projects to African countries is still low, one should not overlook the significant progress made. Indeed, the sharp increase in project proposals during a short time span indicates that progress will continue.

6 CDM projects in Africa

Synopsis

This section map factors that may have influenced development of proposals to apply the CDM in Africa.

The study found that the main host countries for CDM are the largest economies in Africa (Egypt, Morocco, South Africa and Nigeria). Analyses showed a high correlation between countries' economic size, measured in GDP, and the size of their portfolio of CDM project proposals.

The analyses also showed a high correlation between host countries' emission levels and the size of their CDM project portfolios. This appeared to confirm the assumption that CDM projects tend to concentrate in countries with high domestic GHG emissions.

The analyses showed a medium correlation between FDI levels from 1970-2004 and the size of CDM portfolios. However, the correlation was significantly higher for countries that had put in place an institutional CDM framework in the form of a DNA. Additional analyses demonstrated a low to medium correlation between African host countries' general business climate and the size of their project portfolio, but a low correlation between the size of the CDM portfolios and the level of human capital measured by education and health level.

This indicates that a generally "FDI friendly" investment climate could contribute to an African country's ability to benefiting from the CDM facility, but may not be a sufficient factor; a framework to manage the specific tasks related to CDM must also be put in place.

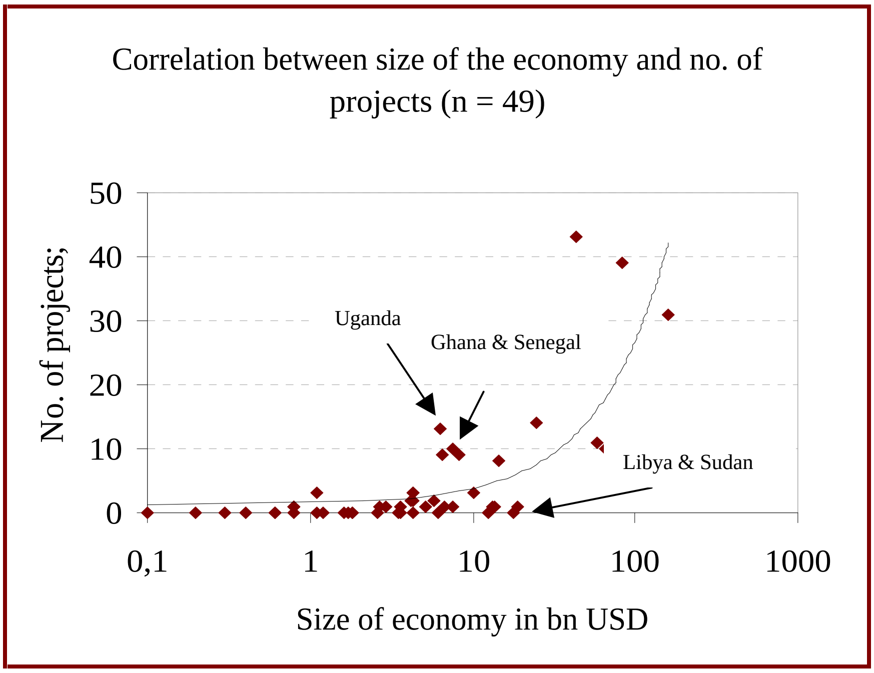
Analysis of countries' technological capacity and the size of their CDM portfolios ranged from medium to high. This indicates that a host country's own technological capacity does influence the development of CDM projects.

What determines the pace of development for CDM proposals in African countries? This section explores the relationship between various enabling factors for investment motivated by CDM and the size of the country's CDM project portfolio. As a measurement of these relationships, the Pearson Correlation Coefficient (R) is computed for each set of parameters.

6.1 CDM, GDP and income level

Can it be confirmed that the largest African economies also have the largest CDM project portfolios? To test this, the size of 49 African economies (measured in GDP in billion USD in 2002 and 2003, online from www.undp.org) and number of known CDM proposals were correlated. The resulting correlation is shown below;

Figure 14: Correlation between size of economy (GDP) and CDM portfolio



(Size of the economy, as GDP, plotted on a logarithmic X-scale)

The results showed a correlation of R=0,747. This is a high correlation and could indicate that the largest countries also have larger CDM portfolios. However, there were some discrepancies that nuance this indication. Some countries seemed to have a larger project portfolio than the size of their economy would suggest, such as Uganda with a GDP of 6,3 bn. USD and a project portfolio of 13, Ghana with GDP of 7,6 bn USD and a project portfolio of 10, and Senegal with a GDP of 6,5 bn USD and 9 CDM projects in its portfolio. Furthermore, some countries seems to have fewer projects than the size of their economy would suggest, such as Sudan with a GDP of 17,8 bn USD but no projects, Libya with a GDP of 19.1 bn USD and one project, and Cote d`Ivoire with a GDP of 13,7 bn USD and also only one project (www.undp.org, and Point Carbons project database).

Uganda was among the early starters in establishing an enabling framework for CDM (Uganda Ministry of water, lands and environment report, 2001:1). Uganda (along with Senegal and Ghana) have, as mentioned in Section 3, participated in several capacity building initiatives, and could have benefited from this by having a relatively large portfolio of projects. By contrast, Cote d’Ivoire and Sudan have been ravaged by civil war, and Libya has been politically isolated (World Bank Africa

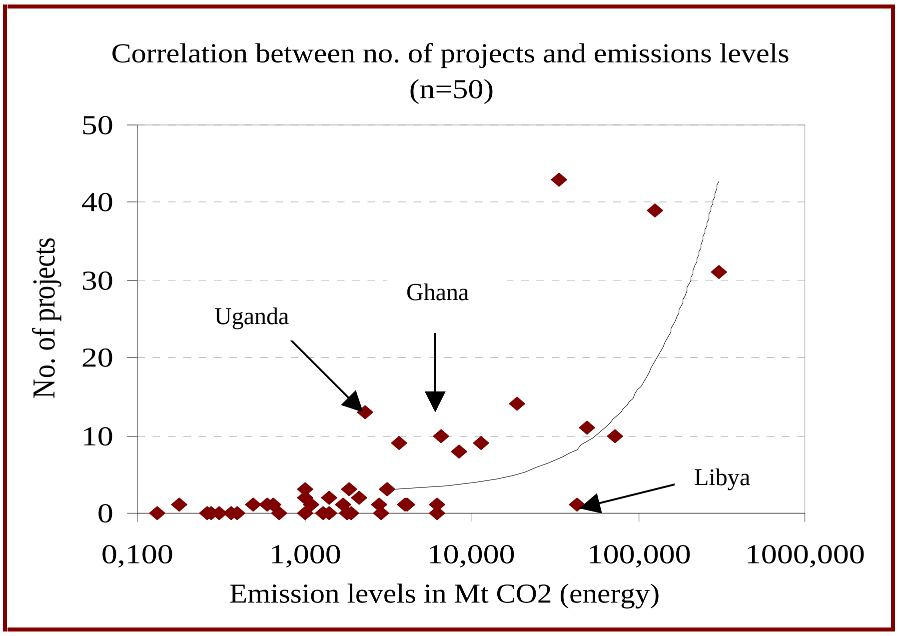
Region, online). These findings indicate that local conditions are important in encouraging CDM development, and can lead to more or fewer proposals than the size of the country's GDP would otherwise suggest.

Which are the other conceivable decisive factors? Perhaps CDM projects develop more frequently in relatively wealthy countries? A correlation analysis was conducted between the GDP per capita in 48 African countries (2003) and the number of known CDM project proposals. This was done in order to assess whether there is a correlation between a country's wealth and development of CDM projects. The chosen variable is GDP per capita as of PPP (Purchasing Power Parity) in USD. The PPP is a more appropriate value of the standard of living in a country because it adjusts GDP per capita with domestic price levels (online from www.undp.org). This analysis showed a low correlation, at R=0,19. This could indicate that wealthier African countries (by the GDP PPP per capita) do not have a proportionately larger CDM portfolio than less wealthy African countries.

6.2 CDM and emission levels

Can it be confirmed that CDM projects will be developed in African countries with higher GHG emissions compared to African countries with low emissions? To test the relationship among CDM projects in Africa and emission levels, the CO_2 levels for 2002 in 50 African countries were compared with the number of known CDM proposals in Africa. The resulting correlation is shown below;

Figure 15: Correlation between CDM proposals and CO_2 levels



(Source: IEA energy outlook, online version; www.iea.org, worldbank.org/Africa, and Point Carbons database. Emission levels plotted on a logarithmic X-scale)

This analysis shows a correlation of R=0,668. This seems to confirm that there is a high correlation between African countries' GHG emissions levels in 2003 and the occurrence of CDM projects. Some countries seemed to have a larger project portfolio than their emission would suggest, such as Uganda and Ghana, or a smaller project portfolio than their emissions would suggest, such as Libya. The causes of these exceptions may be due to the same issues of CDM related institutional capacity and political instability that are mentioned in the previous section.

6.3 CDM and Foreign Direct Investment

Can it be confirmed that CDM is subject to the same laws and economic incentives as FDI, and subsequently follows same routes as FDI? To test the relationship among CDM projects in Africa and FDI, FDI levels for 2004 in 49 African countries (UNCTAD, Foreign Direct Investment Database, online version; wwww.unctad.org) were compared with the number of known CDM project proposals.

The resulting correlation between number of CDM proposals and FDI in 2004 was R=0,330. The result indicates that there is only a medium correlation between a country's present (2004) FDI levels and the number of CDM proposals in that country.

One explanation for this might be that FDI levels may fluctuate substantially from year to year, particularly in small economies in Africa where single incidences of foreign investments may influence the numbers. FDI flows can fluctuate widely during relatively short time periods (OECD, 2002). To eliminate such occurrences, the correlation was also tested between FDI inflows over a longer term (1970 – 2004) (UNCTAD, Foreign Direct Investment Database, online version; wwww.unctad.org) and the number of known CDM project proposals (Point Carbon database). This longer (35 year) time series for FDI could be more indicative of how successful a country has been over a more continuous period in attracting FDI. The resulting correlation was high (R=0,648) when FDI is measured over a longer period.

There are however notable exceptions to the general finding. Angola, which is among the countries in Africa with the highest FDI level, has only one proposed CDM project. One possible explanation for this fact could be that Angola's FDI has been very confined to its offshore petroleum resources (FDI magazine October, 2002).

As the analysis of the size of CDM portfolio compared to the size of economy and emissions levels indicated, some countries have "overachieved" in terms of the volume of projects. This was also the case when comparing with the level of FDI (1970-2004), where "overachievers" included Uganda, Ghana, and Senegal. Uganda has a total of 13 such CDM projects, second only to four other African countries (Point Carbon Project database, 2006). However, Uganda ranks only 22 on the list of FDI recipients (UNCTAD, Foreign Direct Investment Database, online version; wwww.unctad.org). As mentioned above, Uganda, along with Senegal and Ghana, have been in the forefront with respect to creating a CDM enabling environment; this could explain their performance.

The general finding seems to confirm that countries that have been constantly attractive for FDI over a sustained period are also attractive for CDM development. Hence, countries that receive most FDI also have the lion's share of CDM projects**.**

Compared with other developing regions, Africa's composition of FDI inflows (2004) is significantly tilted towards natural resources, particularly in the petroleum industry (UNCTAD, 2005:72). This could complicate the comparison between FDI inflows and CDM prevalence. Moreover, notable exceptions such as Angola (at one end) and Uganda (at the other end) indicate that country-specific circumstances such as the existence of a DNA and/or participation in capacity building projects may slow down or speed up these interlinkages.

6.4 CDM and host country institutions

Can it be confirmed that establishing a host country DNA influences a country's level of CDM project proposals?

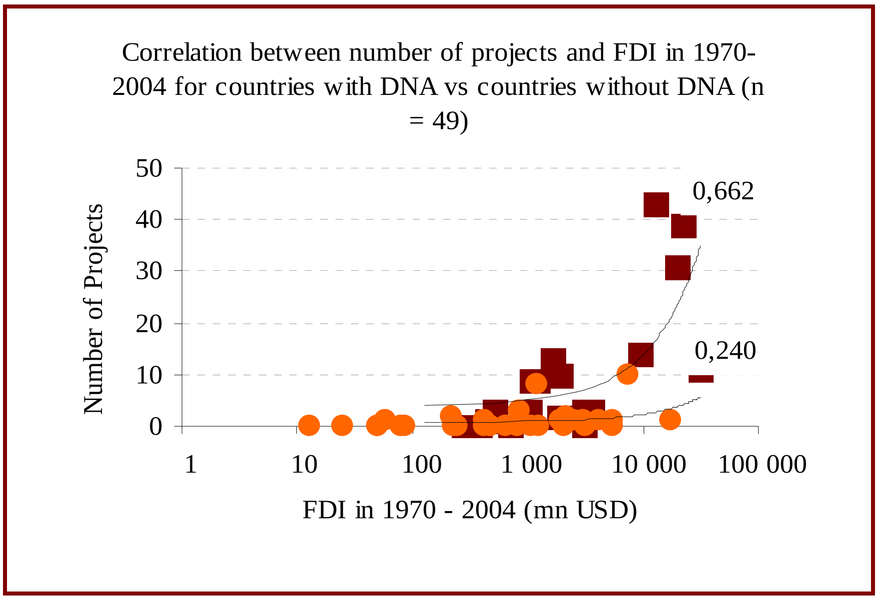
Data on number of projects in all phases were compared with the data on country-wise DNA status from Section 4, to assess whether countries that have established a DNA have a higher frequency of CDM project proposals than countries without a DNA.

The comparison shows that countries that have established a DNA have an average of 9,8 projects. However, if the country has no DNA, the average number of projects falls to 1,1. This could indicate that there is a relationship between a country's establishment of a DNA and its ability to motivate domestic and/or international investors to develop CDM projects.

However, countries that are in the forefront with respect to establishing a DNA may be the same countries that are successful in putting in place other factors required to attract FDI. Hence, the prevalence of projects in these countries could be a result of their general attractiveness for FDI, not of their having a DNA per se.

To explore this, correlation series were drawn up between FDI and number of known CDM projects in 52 African countries with and without DNAs (as established in section 4), respectively. The results are shown below;

Figure 16: Correlation between CDM proposals and FDI in 1970-2004 for countries with DNA vs. countries without DNA



(The orange circles represent countries without DNA whilst the darker red squares represent countries with a DNA. FDI is plotted on a logarithmic X-scale).

This graph demonstrates an interesting fact. In countries without a DNA, there is virtually no relationship between FDI in general and the volume of CDM projects. (R=0,240). In fact, only two countries without a DNA (Algeria and Kenya) have more than three projects. However, in countries with DNA, there is a relationship between the two factors (R=0,662). The findings could indicate that countries that have been successful in attracting FDI in general, have not been able to attract CDM projects, unless they have put in place a DNA. This may confirm that establishing a DNA could therefore be a vital step in broadening the FDI inflows to include CDM related investment.

Information on the timing and the structure of DNA establishment vs. the timing and structure of the investment proposals has not been available. A country that has established a DNA may have done so because a number of projects have already matured to a certain stage. In such cases, DNA establishment has been caused by project proposals, rather than the other way around.

A firm conclusion can therefore not be drawn until the cause-and-effects of the relationship between sizes of CDM portfolios and establishment and effectiveness of host country DNAs have been clarified.

6.5 CDM and business climate

Can it be confirmed that CDM is influenced by the presence of a stable and conducive business climate?

To test the relationship among CDM proposals in Africa and the presence of a good business climate, the Transparency International Corruption Perception Index for 2005 was correlated with the number of known CDM project proposals in Africa. The Corruption Perception Index ranks countries in terms of the degree to which corruption is perceived to exist among public officials and politicians and is based on expert surveys (online from transparency.org). The analysis used data available from 41 countries, and showed a low correlation at R=0,273. This could indicate that corruption is not a significant factor for investors when they assess where to invest in CDM projects.

A further analysis was conducted with the Heritage Foundation’s Economic Freedom Index. The Economic Freedom Index uses 50 independent economic variables to rate countries economic freedom, among them; corruption; non-tariff barriers to trade; the fiscal burden of government, which encompasses income tax rates, corporate tax rates, and trends in government expenditures as a percent of output; rule of law; regulatory burdens on business; labour market regulations, and informal market activities (http://www.heritage.org/). The correlation between the size of 44 African countries CDM portfolios and the Economic Freedom Index values was low, with a close to zero score at R=0,102.

As a final test, the values of the World Economic Forum’s Growth Competitiveness Index and CDM proposals were compared. The Growth Competitiveness Index (GCI) evaluates the role of innovation, technology, public institutions and the macroeconomic environment in selected countries based on a combination of both quantitative data and an executive opinion survey. The values are hence based on both quantitative as well as qualitative data (Lopez-Claros, 2004:96). Data from 24 countries were used; projects with no GCI value were not included in the analysis. The correlation between the two variables scored a medium correlation of R=0,350.

This finding is interesting in that it could indicate that investors' *perception* of host countries business investment climate (measured by the CGI) is more significant for CDM project initiatives than the *actual* host country business climate (measured by the Economic Freedom Index).

The findings in this section seem to indicate that the status of the business climate in African host countries is not a significant factor for CDM development; however investors' *perception* of the business climate could have some influence.

6.6 CDM and Human capital

Can it be confirmed that the quality of a country's human capital influences the level of interest among investors in developing CDM projects there? The relationship between CDM project proposals and host countries quality of human capital was investigated.

Human capital has two important components; the level of education and the level of health in the population (Artadi and Sala-i-Martin, 2003:13). This is because education is needed for workers to make efficient use of complex equipment and machinery (Fafchamps, 2003:76). The level of education can be measured by the level of primary school enrolment, whilst life expectancy is seen as a robust determinant of the general health level (Artadi and Sala-i-Martin, 2003:13). UNDP uses both theses indicators as well as Gross Domestic Capital per capita in their Human Development Index (HDI) Ranking. The HDI values from the ranking (2003, online from http://hdr.undp.org/statistics/data) were compared with the number of known CDM project proposals in 43 African countries. (Countries without a HDI value were not included in the analysis).

The analysis showed a correlation of R=0,343, which is in the lower medium range. The findings do therefore not confirm firmly that that the levels of human capital in the African host country is a decisive factor for the development of CDM projects.

6.7 CDM and Technological Capacity

Can it be confirmed that a country's technological capacity influences its ability to stimulate development of CDM proposals?

The World Bank has developed a set of eight indicators of a country's activity level within science and technology. These indicators are (1) the number of researchers in Research and Development (R&D) per million people; (2) number of technicians in R&D per million people, (3) number of scientific and technical journal articles; (4) expenditure for R&D as a percentage of Gross National Product (GNP); (5) High-technology exports in million USD, (6) High-technology exports in percentage of manufactured exports; (7) receipt of royalty and licence fees in million USD; and (8) payment of receipt of royalty and licence fees in million USD (World Bank, 2005, [online] from worldbank.org).

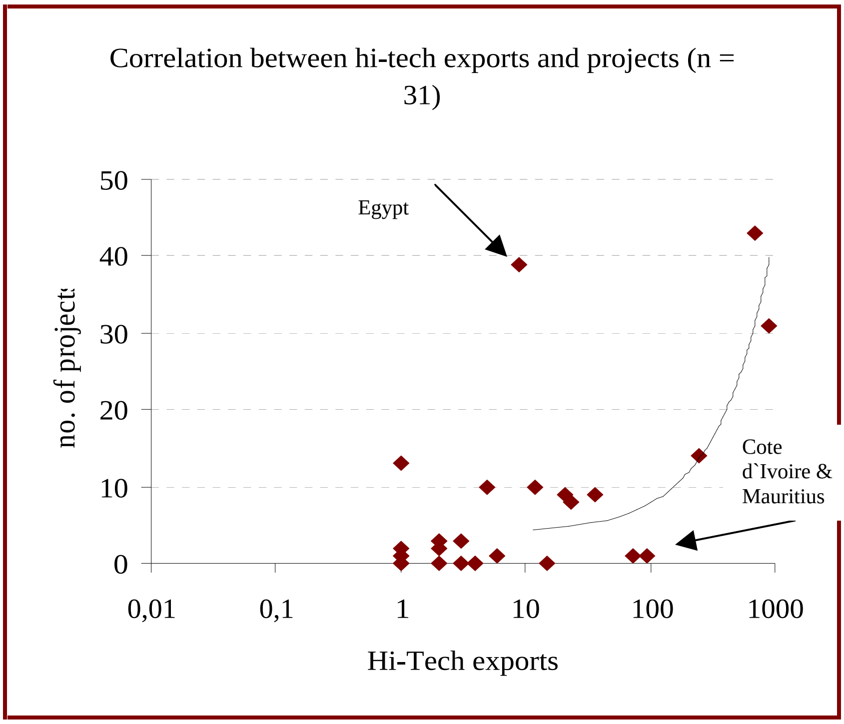
These data were compared with the number of known CDM project proposals, in order to assess whether CDM initiatives are typically developed in countries that already have in place a certain level of scientific and technological activity.

To perform this correlation test, two of the eight indicators were chosen; (3) number of scientific and technical journal articles, and (5) High-technology exports in million USD. The reason for choosing these two indicators among the eight was that they were the two indicators where data were available for most countries.

The correlation factor between the number of scientific and technical journal articles per million inhabitants in 45 African countries and the number of known CDM proposals in Africa was found to be R= 0,77, which demonstrates a high level of correlation. This seems to indicate that there is indeed a relationship between the number of proposals in a country and the technological capacity of that country (measured by number of scientific and technical articles in journals). The correlation is higher than the correlation found between a country's FDI inflows and the number of proposals. This could indicate that a country's level of technological capacity (as measured by the number of scientific and technical journal articles) is more important for attracting CDM than a country's general attractiveness to FDI. However, the scope of the data used here is not broad enough to confirm such a conclusion; more research would be needed to explore the relationships before a firm conclusion could be drawn.

As a second test of the relationships between countries' scientific and technological capacity and CDM prevalence was made. This time, the number of CDM proposals in 31 African countries was compared with a country's technological capacity as measured by its volume of high-technology exports. Countries with no available hi-tech export data were not included in the analysis. The resulting correlation is shown below (linear relation, plotted in a logarithmic X-scale);

Figure 17: Correlation between hi-tech exports and projects

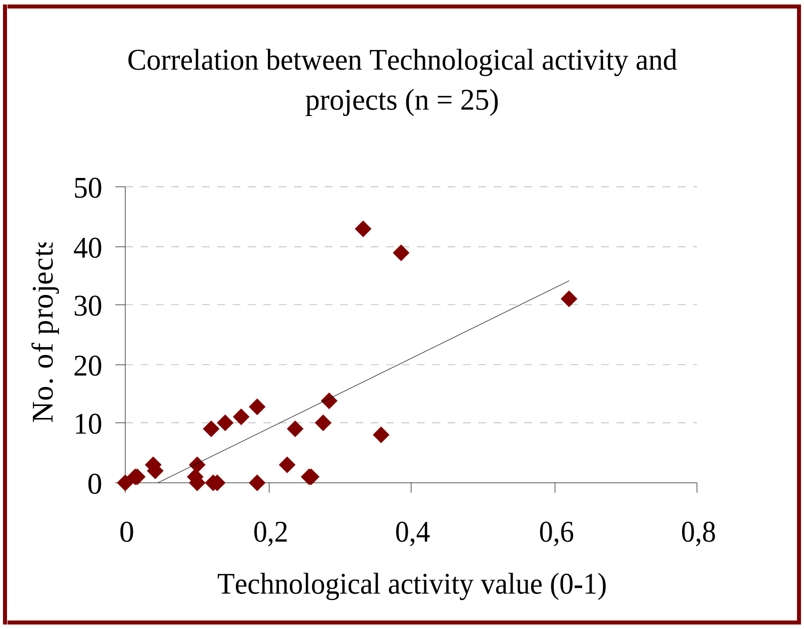


Again, the available data indicate that there is a high correlation between a country's technological performance (measured by high-tech exports) and the size of a country's CDM portfolio. However, there are some important exceptions, and the correlation (R=0,70) is still high but weaker than the same correlation between projects and the number of scientific and technological articles. Important exceptions include Egypt, which is the country with the second highest number of projects, but a rank of only 11th among African countries in terms of high-tech exports. Furthermore, countries such as Cote d'Ivoire and Mauritius have a relatively high exports of high-tech products (World Bank, 2005) but have not seen CDM proposals to any significant extent.

The two indicators above are different in that the first indicator (number of articles per million people) is a measurement of a country's *relative* scientific and technological activity. Large countries will not necessarily score higher than small countries, because the indicator measures the number of articles per million people. By contrast, the second indicator (volume of high-tech exports) is an *absolute* indicator, where large economies may naturally achieve a higher score. The number of projects is also an *absolute* indicator. It is therefore interesting that the highest correlation was found with the *relative* indicator. Could this mean that small countries, with a relatively high scientific and technological activity level, will develop more CDM proposals than the size of their economy should suggest? A further test of this issue was conducted by comparing the extent of CDM portfolios with another relative indicator of technological capacity; namely, the UNCTAD Technological Activity Index.

UNCTADs has rated countries according to their technological activity, where the three variables; R&D manpower, patents in the United States as well as scientific journal articles were given equal weight (UNCTAD, 2005:37). The values can therefore be used when comparing the technological capacity with the number of CDM proposals in Africa. The correlation factor, based on data from 25 countries, was R=0,705. This seems to constitute a further confirmation of the previous finding of this section that technological capacity and activity in host countries can influence the prevalence of CDM proposals. The relation is shown below;

Figure 18: Correlation between Technological activity and CDM proposals



To further broaden the analysis, the World Economic Forum’s Technology Index (one of the three components in the Growth Competitiveness Index, online from http://www.weforum.org/), were compared with the size of CDM portfolios in Africa. Because the World Economic Forum’s index is by a large part based on survey questions, it can be seen as a complement to the previous analysis which were mainly based on empirical data sets such as number of scientific articles, or scientific trained manpower. The Technology Index gives a value on the technological growth potential in countries and incorporates various aspects, such as the role of innovation and technology transfer in the respective countries as well as the use of innovation and communications technology (Lopez-Claros, 2004:109). The ensuing correlation, using data available for 24 African countries, gave a correlation factor of R=0,450. This indicates a correlation of medium strength between the variables.

The above findings concerning the relationship between African countries technological capacity and activity level and the size of their CDM portfolios showed correlation factors ranging from medium to high. The correlation between quantitative measurements such as UNCTADs technological activity index gave higher correlation values than the World Economic Forum's more qualitative technological-sub index. This could suggest that the *actual* technological capacity in African host countries is more significant for CDM development than investors' *perceptions* of the technological capacity in host countries. However, more research is needed before any firm conclusions can be drawn.

6.8 Summary of factors influencing CDM proposals

The following table summarizes the findings of this section;

Table 6: Correlation values [17]

Variable	Pearson's correlation coefficient	Number of samples (n)	Correlation level
Size of economy, GDP USD 2003 (UNDP)	0,747	N = 49	High
GDP per capita PPP USD, 2003 (UNDP)	0,196	N = 48	Low
Total CO_2 emissions, 2002 (fuel combustion only) (IEA, 2004)	0,668	N = 50	High
FDI net inflows USD, 2004 (UNCTAD)	0,330	N = 49	Medium
FDI net inflows USD (1970-2004) (UNCTAD)	0,648	N = 49	High
FDI net inflows USD (1970-2004) for countries with DNA	0,662	N = 20	High
FDI net inflows USD (1970-2004) for countries without DNA	0,240	N = 29	Low
Transparency International Corruption Perception Index, 2005	0,273	N = 41	Low
World Economic Forum Growth Competitiveness Index, 2004	0,350	N = 24	Medium
Heritage Foundation Economic Freedom Index, 2006	0,102	N = 44	Low
UNDP Human Development Index, 2005	0,343	N = 50	Medium

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Scientific and technical journal articles per million inhabitants (World Bank, 2005)	0,770	N = 45	High
Volume of high-technology exports in million USD (World Bank, 2005)	0,700	N = 31	High
UNCTAD Technological Activity Index, 2001	0,703	N = 25	High
World Economic Forum Technology Sub-Index, 2004	0,450	N = 24	Medium

Methodological comments;

- The sections above have explored relationships between pairs of selected parameters. More complex, multi-variable relationships may exist. For example, the size of a country's GDP may influence its FDI inflows, CO_2 emission levels, and volume of high tech exports. The latter factors may, in turn, have an influence on the country's development activity within the CDM field, whilst a concurrent relationship between GDP size and CDM might still exist. However, multi-variable analyses of such a nature have not been possible within the scope of this thesis.
- Furthermore, correlation analysis does not reveal incidences of causality. For example, whilst FDI levels may influence CDM, CDM may also by definition, influence FDI levels, in cases where a foreign partner is involved.

7 Conclusion

Globalization enables and intensifies transfer of capital, technology, know-how, people and ideas across national borders. Meanwhile, the world's climate is undergoing profound changes due to a man-made increase of the concentration of certain GHGs in the atmosphere. Technology is the cause of these changes but also holds the key to solving the problem. The international climate change treaties have developed several mechanisms for stimulating projects that imply reductions in global GHG emissions, while at the same time promoting technology transfer and sustainable development in developing countries. The Clean Development Mechanism is one of these mechanisms, and creates market-driven intercontinental partnerships between governments, private companies, IGOs and NGOs. The CDM can, accordingly, be seen as an illustration of globalization.

Africa contributes very little to global GHG emissions, but will suffer severely from the effects of such emissions. The "win-win" potential of CDM projects is particularly strong in Africa because it can promote transfer of climate friendly technologies, and sustainable development in African countries.

The thesis has confirmed that CDM activity is taking place in Africa, and that it is gathering pace. The conclusion is supported by the identification of over 200 CDM project proposals in African countries, with a total of 39 more developed projects, within technology fields such as renewable energy, waste management and energy efficiency. These 39 projects have developed Project Design Documents (PDDs) and are therefore ready for implementation.

The focus of this thesis was twofold. First, the thesis has set out to map factors that have influenced development of CDM proposals in Africa. The following main issues were addressed;

What has determined the distribution within Africa of CDM proposals? Have the proposals followed the general trend of Foreign Direct Investments (FDI) into Africa? The thesis found that this was partly the case. However, institutional framework for CDM, specific to the host countries, seemed to be a decisive factor. The latter relationship was indicated by the fact that CDM was highly correlated with FDI flows in countries that have established an enabling institutional environment, but only weakly correlated in countries that have not put such an environment in place. Moreover, there seemed to be a medium correlation between the size of countries' CDM portfolios and factors such as business climate or human capital. Use of alternative indices indicated that investors' perceptions of a host country's business climate has been a more decisive factor for driving CDM development than the actual business climate, measured by quantitative variables.

Do CDM projects appear to be more easily accommodated in countries that have already attained a certain level of technological capacity? The analyses conducted seem to confirm this. A high correlation was found between the volume of CDM project proposals and quantitative indicators of technological proficiency. When using a qualitative technology capacity index the result showed a medium correlation. This could indicate that the actual level of technological capacity in host countries is more significant than investors' perception of such capacity.

The second objective of this thesis has been to explore the nature of CDM projects and their potential for facilitating technology transfer to African countries. The following issues were addressed in this respect;

Do the proposed CDM projects involve transfer of climate friendly technology from industrialized countries ("Annex I Parties") to the African host countries? The thesis has confirmed this. Of the 39 proposals reviewed, at least 30% include an element of technology transfer. As a consequence the diffusion of climate friendly technologies to African states may increase and contribute to decreasing the technological gap that exists between industrialized and African countries.

What type of projects will CDM contribute to in Africa? The thesis found that the majority of African CDM projects have taken place within the energy sector. Only a few projects are within the industry sectors. CDM projects within the transport sector are, as of yet, absent in Africa. This may be a result of the general economic profiles of African countries, whose industrial sectors are often relatively minor.

Who develops CDM in Africa? The thesis found that around half of the CDM project proposals in Africa have been developed unilaterally; the other half in a partnerships between a host country entity and an Annex I entity. Furthermore, the study found that the CDM project participants are evenly distributed between public sector entities, private sector entities, and intra-governmental organizations. These findings demonstrate that CDM is indeed a true illustration of the globalization process.

Seen combined, the findings of this thesis underpin the potentially profound implications of the CDM on a broad scale. African countries can take leadership in shaping their own development agenda with respect to introduction of climate friendly technology, by creating conducive institutional arrangements that encourage CDM project development. These projects, as and when carried out, will stimulate sustainable development, which will in turn enhance technological prowess and thereby trigger economic growth, which will in turn generate more CDM projects in a self-reinforcing cycle.

Literature search during the course of the thesis revealed that its subjects have not been covered extensively by previous research. It is therefore hoped that this thesis has represented a first step towards enhanced awareness and interest in this important field.

The CDM is still in a formative period. Few projects have yet been implemented worldwide, let alone in Africa. Only continued research, following closely all aspects of the CDM market as it develops, can confirm whether the mechanism will prove a successful tool for technology transfer to Africa; whether this will promote technological change in the continent, and reinforce its path towards sustainable development.

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Appendix 1: United Nations Framework Convention on Climate Change and Kyoto Protocol

Relevant articles in the United Nations Framework Convention on Climate Change;

Article 2 describes the objective of the convention:" *The ultimate objective of this Convention and any relate legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner".*

Article 4 (c) specifies that: "*All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall: Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors*".

- Article 4.1(h) states that "*All Parties… shall: Promote and cooperate in the full, open and prompt exchange of relevant scientific, technological, technical, socio-economic and legal information related to the climate system and climate change, and to the economic and social consequences of various response strategies".*

- Article 4.3 states that *"The developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations....including for the transfer of technology..".*

- Article 4.5 states that: *"The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the* *transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies".*

Source: UNFCCC (1992) [online] URL: http:// unfccc.int.

Key Articles in the Kyoto Protocol;

- Article 3 (1) states that :" *The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012".*

- Article 6 specifies that: "*For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy*".

- Article 12 states that "*The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3…".*

- Article 17 states that *"The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the* *purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article*….. *"*.

Source: Kyoto Protocol (1997) [online] URL: http://unfccc.int.

Appendix 2: Eligible CDM project categories

Project types	Project activity categories	Illustrative project activities
Type I: Renewable energy projects	**A**. Electricity generation by the user	Photovoltaic's, off grid (Solar home systems, public systems.) Solar water pumping Solar desalination Small hydro Small wind power Wind battery chargers Oil-plants (Jatropha, Biodiesel etc.) fuelled generation
	B. Mechanical energy for the user	Water mills Wind-powered mechanical water pumps
	C. Thermal energy for the user	Solar water heating Solar Dryers Solar cookers Farm/enterprise scale biogas Improved cooking stoves Biomass combustion for water heating/space heating & drying Biomass fueled cogeneration
	D. Renewable electricity generation for a grid	Hydro power Wave power Tidal power Turbine upgrading/replacement, etc. Large photovoltaic's Solar thermal power Wind/diesel units Large off shore wind turbine Large on shore wind turbine Larger biogas plants Landfill gas plants Biomass gasification Biomass fuelled cogeneration Waste fuelled power Landfill gas plants Geothermal power
Type II: Energy efficiency	**A**. Supply side energy efficiency improvements	Electricity transmission and distribution,

improvement projects	- transmission and distribution	efficiency improvement Heat transmission and distribution, efficiency improvement
	B. Supply side energy efficiency improvements - generation	Efficiency improvement at power plants Efficiency improvement at district heating plants Efficiency improvement at district heating plants
	C. Demand-side energy efficiency programmes for specific technologies	Higher efficiency lighting Higher efficiency refrigerators/freezers Higher efficiency fans/air conditioning Higher efficiency electric motors Other improved household electrical appliances Other improved service electrical equipments Other improved industrial electrical equipments
	D. Energy efficiency and fuel switching measures for industrial facilities	Energy efficiency measures (motors, pumps, cooling etc) Fuel switching with energy efficiency as primary aim More efficient industrial processes (steel, paper, tobacco, etc.)
	E. Energy efficiency and fuel switching measures for buildings	Energy efficiency measures (appliances, better insulation, etc.) Fuel switching with energy efficiency as primary aim
	F. Energy efficiency and fuel switch for agricultural facilities and activities	
Type III: **Other project activities**	**A**. Agriculture	Manure management (CH4 & N2O) Water management in rice cultivation (CH4) Improved fertilizer usage (N2O)
	B. Switching fossil fuels	Fuel switching as primary aim (energy efficiency can be included)
	C. Emission reductions by low-greenhouse emission vehicles	A number of vehicles is replaced with lower emission vehicles

	D. Methane recovery	Methane recovery from coalmines, agro-industries, or other sources
	E. Avoidance of methane production from biomass decay through controlled combustion	
	F. Avoidance of methane production from biomass decay through composting	
	G. Landfill methane recovery	
	H. Methane recovery in wastewater treatment	
	I. Avoidance of methane production in wastewater treatment through replacement of anaerobic lagoons by aerobic systems.	

(Source: http://cdm.unfccc.int/methodologies)

Appendix 3: African countries and ratification of the Convention and Protocol

Country	Convention ratification as of 24/05/04	Kyoto Ratification as of 27/02/06
Algeria	09/06/93 (R)	16/02/05 (Ac)
Angola	17/05/00 (R)	
Benin	30/06/94 (R)	25/02/02 (Ac)
Botswana	27/01/94 (R)	08/08/03 (Ac)
Burkina Faso	02/09/93 (R)	31/03/05 (Ac)
Burundi	06/01/97 (R)	18/10/01 (Ac)
Cameroon	19/10/94 (R)	28/08/02 (Ac)
Cape Verde	29/03/95 (R)	10/02/06 (Ac)
Central African Republic	10/03/95 (R)	
Chad	07/06/94 (R)	
Comoros	31/10/94 (R)	
Congo, Democratic Republic of	09/01/95 (R)	23/03/05 (Ac)
Congo, Republic of	14/10/96 (R)	
Côte d'Ivoire	29/11/94 (R)	
Djibouti	27/08/95 (R)	12/03/02 (Ac)
Egypt	05/12/94 (R)	12/01/05 (R)
Equatorial Guinea	16/08/00 (Ac)	16/08/00 (Ac)
Eritrea	24/04/95 (Ac)	28/07/05 (Ac)
Ethiopia	05/04/94 (R)	14/04/05 (Ac)
Gabon	21/01/98 (R)	
Gambia	10/06/94 (R)	01/06/01 (Ac)
Ghana	06/09/95 (R)	30/05/03 (Ac)
Guinea	07/05/93 (R)	07/09/00 (Ac)
Guinea-Bissau	27/10/95 (R)	18/11/05 (Ac)
Kenya	30/08/94 (R)	25/02/05 (Ac)
Lesotho	07/02/95 (R)	06/09/00 (Ac)
Liberia	05/11/02 (R)	05/11/02 (Ac)
Libya	14/06/99 (R)	

Madagascar	02/06/99 (R)	24/09/03 (Ac)
Malawi	21/04/94 (R)	26/10/01 (Ac)
Maldives	09/11/92 (R)	30/12/98 (R)
Mali	28/12/94 (R)	28/03/02 (R)
Mauritania	20/01/94 (R)	22/07/05 (Ac)
Mauritius	04/09/92 (R)	09/05/01 (Ac)
Morocco	28/12/95 (R)	25/01/02 (Ac)
Mozambique	25/08/95 (R)	18/01/05 (Ac)
Namibia	16/05/95 (R)	04 /09/03 (Ac)
Niger	25/07/95 (R)	30/09/04 (R)
Nigeria	29/08/94 (R)	10/12/04 (Ac)
Rwanda	18/08/98 (R)	22/07/04 (Ac)
São Tomé and Príncipe	29/09/99 (R)	
Senegal	17/10/94 (R)	20/07/01 (Ac)
Seychelles	22/09/92 (R)	22/07/02 (R)
Sierra Leone	22/06/95 (R)	
Somalia		
South Africa	29/08/97 (R)	31/07/02 (Ac)
Sudan	19/11/93 (R)	02/11/04 (Ac)
Swaziland	07/10/96 (R)	13/01/06 (Ac)
Tanzania	17/04/96 (R)	26/08/02 (Ac)
Togo	08/03/95 (At)	02/07/04 (Ac)
Tunisia	15/07/93 (R)	22/01/03 (Ac)
Uganda	08/09/93 (R)	25/03/02 (Ac)
Zambia	28/05/93 (R)	
Zimbabwe	03/11/92 (R)	

(Source: Ratification status, [online], URL: http://unfccc.int)

R= Ratification

Ac = Accession

At = Acceptance

Appendix 4: Values and Indices

Economy	Size of economy in bn USD 2003 (UNDP)	Emissions MtCo2 (fuel combustion only) (IEA)	GDP per capita PPP USD, 2003 (UNDP)	Scientific and technical journal articles per million inhabitants (World Bank, 2005)	Growth Competitiveness Index score 2004 (World Economic Forum) (1-7)	Technology Sub-Index score 2004 (World Economic Forum) (1-7)
Algeria	66,5	73,29	6107	225	3,39	2,48
Angola	13,2	6,31	2344	3	2,60	2,43
Benin	3,5	1,8	1115	20	-	-
Botswana	7,5	4	8714	41	4,56	3,78
Burkina Faso	4,2	1	1174	23	-	-
Burundi	0,6	0	648	3	-	-
Cameroon	12,5	2,89	2118	75	2,98	2,80
Cape Verde	0,8	0,13	5214	-	-	-
CAR	1,2	0,37	1089	-	-	-
Chad	2,6	0	1210	2	2,31	2,06
Comoros	0,3	0	1714	-	-	-
Congo	3,6	0,6	965	13	-	-
Côte d'Ivoire	13,7	1,1	1476	40	-	-
Dem, Rep, of the Congo	5,7	2,14	697	6	-	-
Djibouti	0,6	0	2086	-	-	-
Egypt	82,4	126,81	3950	1548	3,84	3,64
Equatorial Guinea	2,9	0,18	19780	-	-	-
Eritrea	0,8	0,65	849	2	-	-
Ethiopia	6,7	4,15	711	93	2,92	2,17
Gabon	6,1	1,29	6397	20	-	-
Gambia	0,4	0,26	1859	17	3,93	3,22
Ghana	7,6	6,57	2238	90	3,46	3,10
Guinea	3,6	1,14	2097	2	-	-
Guinea-Bissau	0,2	0,28	711	6	-	-
Kenya	14,4	8,49	1037	230	3,21	3,36
Lesotho	1,1	0	2561	1	-	-
Liberia	-	0,31	-	1	-	-
Libya	19,1	42,59	7570 (2002)	19	-	-
Madagascar	-	-	809	-	2,85	2,47
Malawi	1,7	1	605	36	3,36	2,79

Mali	4,3	1	994	11	2,79	2,36
Mauritania	1,1	3,1	1766	2	-	-
Mauritius	5,2	2,8	11287	16	4,12	4,10
Morocco	43,7	33,26	4004	469	3,77	3,50
Mozambique	4,3	1,41	1117	14	2,91	2,84
Namibia	4,3	1,9	6108	13	3,99	3,72
Niger	2,7	1,7	835	21	-	-
Nigeria	58,4	49,81	1050	332	3,10	3,16
Rwanda	1,6	0,7	1268	4	-	-
Sao Tome and Principe	0,1	0	1231	-	-	-
Senegal	6,5	3,71	1648	62	3,34	3,04
Seychelles	0,7	-	10232	-	-	-
Sierra Leone	0,8	0,5	548	3	-	-
Somalia	-	-	-	-	-	-
South Africa	159,9	301,48	10346	2327	4,37	4,35
Sudan	17,8	6,2	1910	43	-	-
Swaziland	1,8	0,4	4726	6	-	-
Tanzania	10,3	3,18	621	87	3,49	3,22
Togo	1,8	1,8	1696	11	-	-
Tunisia	25	18,76	7168	344	4,49	3,90
Uganda	6,3	2,3	1457	91	3,25	3,25
Zambia	4,3	1,87	877	26	3,10	2,96
Zimbabwe	8,3	11,43	2443	113	2,84	3,34

Economy	Economic Freedom Index Value (Heritage Foundation)(5-1)	Transparency Corruption Perception Index Value 2005 (1-10)	Human Development Index Value 2005 (UNDP) (0-1)	FDI net inflows Million USD (1970-2004) (UNCTAD)	FDI net inflow 2004 Million USD (UNCTAD)	Technological Activity Index Value 2001 (UNCTAD) (0-1)
Algeria	3,46	2,8	0,722	7423	881,9	0,278
Angola	3,84	2,0	0,445	17347	2047	0,013
Benin	3,40	2,9	0,431	702	60	0,122
Botswana	2,29	5,9	0,565	1897	46,8	0,261
Burkina Faso	3,28	3,4	0,317	221	35	-
Burundi	3,69	2,3	0,378	51	3	-
Cameroon	3,46	2,2	0,497	1054	0,29	0,102
Cape Verde	2,69	-	0,721	228	20,4	-
CAR	3,42	-	0,355		-12,6	-
Chad	3,29	1,7	0,341	3152	478	-
Comoros	-	-	0,547	25	2	-
Congo	3,90	2,3	0,512	3098	668,3	-
Côte d'Ivoire	3,14	1,9	0,420	4201	360	0,097
Dem, Rep, of the Congo	-	2,1	0,385	1874	900	-
Djibouti	3,20	-	0,495	85	33	0,000
Egypt	3,59	3,4	0,659	22237	1253,3	0,387
Equatorial Guinea	3,74	1,9	0,655	5491	1664	-
Eritrea	-	2,6	0,444	422	30	0,017
Ethiopia	3,70	2,2	0,367	2556	545	0,059
Gabon	3,28	2,9	0,635	242	322,7	-
Gambia	3,51	2,7	0,470	425	60	-
Ghana	3,29	3,5	0,520	1917	139,2	0,139
Guinea	3,55	-	0,466	474	100	-
Guinea-Bissau	3,65	-	0,348	51	5	-
Kenya	3,20	2,1	0,474	1223	46	0,358
Lesotho	3,24	3,4	0,497	479	51,8	-
Liberia	-	2,2	-	3001	20	-
Libya	4,16	2,5	0,799	-3998	-	-
Madagascar	2,75	2,8	0,499	513	45	0,195
Malawi	3,63	2,8	0,404	379	16	0,130
Mali	3,14	2,9	0,333	1039	180	-
Mauritania	3,08	-	0,477	864	300	0,038
Mauritius	3,03	4,2	0,791	887	65,3	0,257
Morocco	3,21	3,2	0,631	12636	853	0,332

Mozambique	3,35	2,8	0,379	2166	131,9	0,042
Namibia	-	4,3	0,627	2075	286	0,185
Niger	3,38	2,4	0,281	445	20	-
Nigeria	4,00	1,9	0,453	31402	2127	0,161
Rwanda	3,53	3,1	0,450	279	10,8	-
Sao Tome and Principe	-	-	0,604	79	54	-
Senegal	3,10	3,2	0,458	1065	70	0,120
Seychelles	-	4,0	0,821	808	60	-
Sierra Leone	3,76	2,4	0,298	59	4,8	-
Somalia	-	2,1	-	13	9	-
South Africa	2,74	4,5	0,658	19305	584,9	0,621
Sudan	-	2,1	0,512	5545	1511	-
Swaziland	3,04	2,7	0,498	1238	68,6	-
Tanzania	3,20	2,9	0,418	3521	469,9	0,277
Togo	3,71	-	0,512	637	60	-
Tunisia	-	4,9	0,753	9528	638,9	-
Uganda	2,95	2,5	0,508	1633	237	0,185
Zambia	3,34	2,6	0,394	3019	334	0,101
Zimbabwe	4,23	2,6	0,505	1204	60	0,327

Economy	Volume of high-technology exports in million USD (World Bank, 2005)		Volume of high-technology exports in million USD (World Bank, 2005)		Volume of high-technology exports in million USD (World Bank, 2005)
Algeria	12	Ethiopia	-	Niger	1
Angola	-	Gabon	-	Nigeria	-
Benin	-	Gambia	-	Rwanda	1
Botswana	6	Ghana	5	Sao Tome and	-
Burkina Faso	1	Guinea	-	Senegal	36
Burundi	-	Guinea-Bissau	-	Seychelles	-
Cameroon	3	Kenya	23	Sierra Leone	1
Cape Verde	-	Lesotho	-	Somalia	-
CAR	-	Liberia	-	South Africa	908
Chad	-	Libya	-	Sudan	4
Comoros	-	Madagascar	-	Swaziland	4
Congo	-	Malawi	1	Tanzania	3
Côte d'Ivoire	93	Mali	2	Togo	2
Dem. Rep. of the	-	Mauritania	-	Tunisia	244
Djibouti	-	Mauritius	72	Uganda	1
Egypt	9	Morocco	680	Zambia	2
Equatorial Guinea	-	Mozambique	2	Zimbabwe	21
Eritrea	-	Namibia	15		